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FITNESS LEVELS OF A RURAL POPULATION AGED THIRTY TO EIGHTY-FIVE

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "FITNESS LEVELS OF A RURAL POPULATION AGED THIRTY TO EIGHTY-FIVE" submitted by GLEN EDWARD BAILEY in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

This thesis was comprised of a main study and a secondary study.

The purpose of the main study was to assess the physical fitness levels of a rural male population in Manitoba 30 years of age and over from the measurements of estimated MVO_2 determined by the Astrand-Rhyming nomogram from one six-minute submaximal work load on a Monark bicycle ergometer, vital capacity, skinfold thicknesses, which included the biceps, triceps, subscapula and suprailiac, percent body fat and hand grip strength. A total of 312 individuals participated in this study.

One-way analyses of variance and Newman-Keuls comparisons between ordered means were employed to test the difference between five year age groups.

The purpose of the secondary study was to determine the actual MVO_2 on a separate group of rural males in Manitoba, 30 years of age and over; all actively engaged in farming. A total of 47 subjects participated in this study. Observed MVO_2's were determined using a continuous test (two six-minute submaximal work loads and one three-minute maximal work load), employing the Monark bicycle ergometer. Estimated MVO_2's were determined from the second submaximal work load. A t-test was employed to test the differences between the overall means of the observed and estimated MVO_2's.

Subsidiary purposes were to compare the MVO_2 results from the main and secondary studies, compare these values with data from the literature

and compare vital capacity, skinfolds and percent body fat and hand grip strength data from the main study with data from the literature in ten year age groups.

The results showed that estimated and actual MVO_2's (both studies) vital capacity and hand grip strength (main study) decreased with age and skinfold thicknesses and percent body fat (main study) remained relatively constant.

The overall mean actual MVO_2 (secondary study) was 16.5% greater than the overall mean estimated MVO_2 (secondary study) ($p > 0.01$) and 24.4% greater than the overall mean estimated MVO_2 determined from the main study.

The mean estimated MVO_2's (main and secondary studies) arranged in ten year age groups were generally below corresponding mean values when compared with data from the literature, including sedentary groups, but the mean observed values for each age group (secondary study) were generally higher than the values for sedentary groups and lower than the values for active and athletic groups. Mean vital capacity measurements (main study) compared favourably with data from the literature and mean hand grip strengths (main study) were generally higher compared to other populations.

Mean skinfold thicknesses (triceps and subscapula) measured in the main study were generally less compared to sedentary populations, especially when compared to populations in North America.

It was concluded that the Canadian farmer (at least in Manitoba) is more physically fit than sedentary populations based on the observed

MVO_2 results obtained in the secondary study. The differences between the farm population and sedentary populations are not large, however, and may be due to the increased mechanization of farming operations, thus reducing the demand for hard physical exertion. From the large differences between estimated and actual MVO_2's from the two studies it was concluded that the correction factor based on age to determine estimated MVO_2 reduces the individual MVO_2 value too severely. A better estimation is gained by correcting the MVO_2 values based on mean maximal heart rate for each age group.

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Physical fitness has been defined as the ability of the organism to maintain various equilibria as closely as possible to the resting state during strenuous exertion and restore promptly after exercise any equilibriums which have been disturbed (13). The assessment of physical fitness, however, remains a controversial problem in exercise physiology because of various opinions as to what actually constitutes fitness and the types of measurements that are required to make valid comparisons between individuals (13). The problem has not been alleviated by the multitude of tests available to measure fitness, primarily because of the lack of correlation between them (40, 43, 47).

The maximal oxygen uptake (MVO_2) or aerobic power, has been defined as the ability of the cardio-respiratory system to take up, transport and give off oxygen to the working muscles (10). While this measurement is considered by most exercise physiologists to be the best single indicator of endurance fitness (10, 13, 18, 40, 100), in terms of the ability to perform prolonged moderate to heavy work, there has been a tendency to oversimplify the problems of assessing physical fitness by relying solely on this parameter. As a result, other important parameters of fitness have been neglected (5, 40). Andersen (5) has contended that the determination of physical fitness must involve basic measurements into body composition and the physiological status of the body as

a whole, which comprise:

1. size, shape and composition of the body,
2. aerobic and anaerobic components of metabolism,
3. muscles in static and dynamic work, and
4. the circulatory and respiratory systems.

Methods for the actual measurement of MVO_2 have been employed for some time, but are not suitable for surveys on large numbers of subjects. Various techniques have recently been developed which are suitable for estimating the MVO_2 (12, 77, 78) if properly standardized and applied (99, 102, 106, 107, 118, 125). Much of the work on estimation techniques has been completed in conjunction with the International Biological Programme (IBP) (99, 102, 124). Numerous techniques have been designed for the assessment of anthropometric characteristics, such as skinfold thicknesses (4, 27, 29, 31, 35, 53, 69, 71, 87, 105, 111) and the estimation of percent body fat from skinfold measurements (1, 7, 39, 49, 56, 68, 85, 110), which are readily applied in large surveys. Respiratory functions are relatively easy to assess in field surveys, while strength measurements have been difficult to standardize and apply in the same conditions (43).

The determination of the physical fitness levels of various populations has become important for many reasons, of which a number have been discussed by Andersen (5), Astrand et al. (12), Christensen (36), Cumming (40, 41), Davies (46) and Shephard (100). Weiner (120) has outlined the necessity for the accumulation of data on fitness parameters, as an integral part of the objectives of the IBP.

Unfortunately the bulk of knowledge available from various populations is restricted to a small number of samples lacking standardization of measurement techniques and the types of measurements for determining physical fitness (5, 13). There has been a lack of description of the factors which may modify results, a few of which are: environment, nutrition and health status at the time of testing, drinking and smoking habits and activity levels - whether recreational or occupational (100). When different national or regional groups are compared, genetic background should be considered (40, 120). The majority of sample populations observed to date have not been randomly selected, although random samples are difficult to study (18), and the number of subjects by age category or in total have generally been small. In addition, most samples have been drawn from social and occupational groups in urban settings, primarily because of convenience and accessibility. Some insight has been gained, but much more remains to be accomplished before a more complete picture emerges concerning the physical fitness status of contrasting populations from various regions of the world (5).

Provided that nutritional status is optimal, habitual physical activity appears to be the most powerful factor influencing the fitness level of a healthy individual. In all societies, manpower is an important factor in production and in developing and maintaining favourable living conditions. The amount and nature of the physical exertion required in various occupations will depend on climate, the degree of industrialization and the cultural and social structure of the society. The contrasts in this respect between primitive societies and highly

mechanized nations are considerable (5).

It has been well established that deliberate training may increase the MVO_2 by 20% or more (18), and the decline in MVO_2 with age may be partially prevented by regular vigorous activity (37, 38). In addition, there is some evidence that physical fitness levels (in terms of aerobic power) are higher in individuals engaged in occupations which require considerable energy expenditure, compared to those in more sedentary occupations (I. Astrand in 18:309). In contrast, Andersen has shown that there is little difference in aerobic power between active and sedentary groups in the respective occupations (5).

Traditionally, farming has been hard work, especially in the busy season, and where the advantage of mechanization is not present. Mechanization of the farming industry in many parts of the world has improved production tremendously, but at the same time has decreased the physical exertion required to fulfill the particular jobs. Little evidence is available on the fitness levels of individuals engaged in farming, although various farming activities have been analyzed in terms of energy requirement, expressed as kilocalories per minute (48, 86).

Regardless of the individual's occupation, it is evident that the decrease in physical activity due to automation, with the resulting decrease in aerobic power, may have deleterious effects on man's health in terms of resistance to disease, longevity, adaptive capability and well being. Scientific validation of these possible effects requires a great deal of further study (5).

The Problem

Main Problem

The purpose of the main study was to assess the physical fitness levels of a sample of males engaged in the farming industry, 30 years of age and over throughout rural Manitoba. The evaluation was carried out employing four parameters of fitness, including estimated MVO_2, vital capacity, skinfold thicknesses and percent body fat and grip strength, with comparisons made between five year age groups.

Subsidiary Problems

Secondary problems were to:

1. compare the mean actual and estimated MVO_2 values from a secondary sample of males engaged in farming, between five year age groups,
2. compare the mean actual and estimated MVO_2 values from the secondary sample with the mean estimated MVO_2 values obtained in the main study, between each age category, and
3. compare the mean values (by ten year age groups) of the four parameters from the main study and the actual and estimated MVO_2's from the secondary study, with data selected from the literature.

Justification for the Study

The majority of studies on occupational groups have been completed on urban samples, primarily because of convenience. Little data is

available on individuals whose occupation is farming, particularly in Canada where the farming industry has been highly mechanized. It is not known whether the various physical activities required in farming operations have any effect on aerobic power or other parameters of physical fitness.

Limitations - Main and Secondary Studies

1. The subjects in both studies were not randomly selected.
2. Temperature and humidity were not strictly controlled in either study.
3. There was no control over the time at which subjects were tested, particularly in the main study.
4. There was no control over food, alcohol or cigarette consumption prior to testing in either study.
5. All subjects in both studies were unfamiliar with the test items and procedures.
6. Comparison of results with data from the literature is subject to further limitations, including
   (a) lack of random selection of subjects to represent various areas and countries,
   (b) a generally small number of subjects,
   (c) use of different test procedures and apparatus,
   (d) lack of information, or accounting for environmental, nutritional and genetic factors and activity levels, and
   (e) adaptation of subjects to test procedures.

Delimitations - Main and Secondary Studies

1. The main study was delimited to the testing of males throughout rural Manitoba, 30 years of age and over.
2. The secondary study was delimited to the testing of males from one rural municipality in Manitoba, 30 years of age and over.
3. In the main study, only those localities were selected which allowed continuity in terms of time and distance from Winnipeg.
4. In the main study, the test period was determined between June 11 and July 31, 1971.
5. In the main study, the fitness tests were limited to estimated MVO_2 (10, 12), skinfold thicknesses and percent fat (49), vital capacity and grip strength.
6. For the purposes of this study, only the estimated and actual data on the MVO_2 from the secondary study was used.
7. The actual MVO_2 in the secondary study was determined from a 15 minute continuous test (two submaximal work loads of six minutes each, and one maximal work load lasting three minutes).

Definition of Terms

Physical fitness (endurance fitness, physical work capacity) - the ability of the organism to maintain various equilibria as closely as possible to the resting state during strenuous exertion and restore promptly after exercise any equilibriums which have been disturbed (13). These terms have also been used synonymously to describe the ability

of the oxygen transport system to take up, transport and give off oxygen to the exercising muscles (10). A further definition has been the ability to perform prolonged moderate to heavy work, provided that large muscle groups are utilized (18).

Maximal oxygen uptake (MVO_2, VO_{2max}, aerobic power, aerobic capacity). These terms have been used to describe physical fitness and is the ability of the oxygen transport system to take up, transport and give off oxygen to the working muscles (10). In the secondary study, the MVO_2 was the value attained after one maximal effort of three minutes duration on a bicycle ergometer, performed immediately after two-six minute submaximal work loads.

Predicted MVO_2 - the estimation of the MVO_2 from the linear relationship between oxygen uptake and heart rate relative to work load (12). In the main and secondary studies, estimated MVO_2 was determined from one submaximal work load employing the nomogram of Astrand and Rhyming (12) and correcting for age after the method of Astrand (10).

Submaximal work load - a work load at which the individual is able to perform such that aerobic processes meet oxygen demands of the working muscles (18).

Submaximal heart rate - the heart rate associated with a particular submaximal work load in which the heart rate reaches a steady state - usually within five minutes (18).

Steady state - the adaptation of cardiac output, heart rate and pulmonary ventilation to a work situation where oxygen uptake equals oxygen requirement of the tissues with no accumulation of lactic acid in the body (18).

Skinfold measurement - the measurement of a double layer of subcutaneous fat and skin by a suitable caliper. In the main study, the measurements were taken employing a Harpenden skinfold caliper (29).

Percent fat - the estimation of the proportion of the body mass which is fat which may be calculated by a variety of methods (30). In the main study, percent fat was calculated from the percent fat table developed by Durnin et. al. (49) from densitometric and skinfold regression formulae.

Vital capacity - the maximal amount of gas that can be expelled from the lungs following a maximal inspiration (25), measured in liters.

Grip strength - the maximal isometric force exerted by the flexors of the hand and forearm in a single voluntary effort and measured by a suitable recording device (73).

Main study - the physical fitness survey completed in the summer of 1971 on a rural and farm population in the province of Manitoba, involving male volunteer subjects 30 years of age and over.

Secondary study - the physical fitness survey completed in the spring of 1969 on a farm population from one rural municipality in Manitoba, involving male volunteer subjects 30 years of age and over. The main purpose of the survey was to measure the MVO_2 directly.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Physical fitness surveys are becoming an increasingly important tool for those engaged in the medical and para-medical professions. In addition to providing a general contribution to scientific knowledge, the data collected from population studies may be used in a variety of ways, depending on the purposes for which a particular study is carried out (5, 12, 36, 40).

There have been, and still are, a number of problems to consider when carrying out a physical fitness survey, one of which is the definition of physical fitness and how to measure it (13, 40, 41). Most exercise physiologists today consider the MVO_2 to be the best single indicator of physical fitness, in terms of the ability to perform prolonged moderate to heavy work, utilizing large muscle groups (13, 40, 100). This parameter may be measured with precision in the laboratory, but requires a great deal of time and equipment. For this reason and others (12, 125), the actual measurement of the MVO_2 is not practical in population surveys. It is now possible, however, to predict the MVO_2 from a submaximal work test (12, 77, 78, 92) quickly and without undue discomfort to the subject. The technique, if properly standardized (106, 118, 119) and used only when the relationship between the estimated and actual MVO_2 values are known for the population under study (41), is considered a valid field test for comparisons between population samples (41, 106).

The MVO_2 test should not be the sole measure of physical fitness, since other parameters provide valuable information which are regarded as necessary for a more complete assessment of this complex phenomenon. These include anthropometric measures, such as skinfold thicknesses and strength items (5, 40). A considerable number of studies have been completed involving various methods of estimating percent body fat (1, 20, 21, 24, 28, 30, 39, 70, 84, 89, 108, 112), including methods which are applicable in field studies employing the skinfold caliper technique (23, 27, 29, 31, 39, 49, 50, 51, 53, 56, 69, 70, 85, 87, 105, 110, 111, 116). The techniques for measuring the strength of various body segments are difficult to standardize and apply in large surveys (43) and it becomes a matter of deciding which measurements to use in relation to the objectives and scope of the study.

Various other problems are encountered in population surveys, involving comparison with other surveys, regarding - activity levels, age groups, methodology, nutritional status, genetic differences, health status at the time of testing etc. Proper assessment of all of these factors and the effects they may have on the results of the various measurements taken, are beyond the scope of most surveys.

Problems in Conducting Physical Fitness Surveys

There is little comprehensive knowledge at present on the physical fitness levels of various populations throughout the world. The available data has been criticized for lack of standardization of measurement techniques (5, 13, 40), lack of random sampling (5, 40, 100, 114) and

the inadequacy of describing factors which may influence test results (100). The majority of studies have only included measurement of aerobic power, and it has been recommended that for a more valid assessment of physical fitness, anthropometric measurements (skinfolds and percent body fat) and strength items should be included (5, 40). Further recommendations have been made by Weiner (120), including the selection of samples and subsamples within various regions and countries, taking into account contrasting climatic, occupational, nutritional and genetic backgrounds.

Much of the work has been completed on the requirements and methodology necessary for collecting data on the presently accepted parameters of physical fitness (29, 99, 101, 102, 105, 116) but the logistics in conducting a particular survey remain a problem (41).

The Maximal Oxygen Uptake

Most exercise physiologists are of the opinion that physical fitness is best measured by assessing the maximal oxygen uptake (13, 40, 100), but has been accepted with some reservation by others (46). Interest in the determination of the MVO_2 dates back to the work of Hill et al. (65) in the 1920's. A great deal of theoretical and practical knowledge on the MVO_2 has been accumulated since these classic experiments. Some of this knowledge includes, the 'levelling off' phenomenon demonstrated by Astrand (11) and others (81, 117, 122), the determination of the MVO_2 from the performance of various activities (14) and the comparison of different methods for determining the MVO_2 (15, 16,

58, 64, 99, 101). Work has also been completed demonstrating the relationship of the MVO_2 to other physiological parameters, such as certain anthropometric measures (33). Theories have been advanced concerning the factors which may limit the MVO_2 (9, 66, 81, 113, 114) and the effects of training on the oxygen transport system have been thoroughly examined (18, 37, 38, 40, 60, 61, 62, 80, 82, 83, 91, 96, 97, 109). The majority of this work has been completed on young and selected subjects able to withstand the considerable stress of maximal exertion.

For various reasons, including safety, it became necessary to develop a work capacity test which was submaximal in nature and which could estimate the MVO_2 with reasonable accuracy. This test was first developed by Astrand and Rhyming (12), employing a treadmill, bicycle ergometer or step-test. The test was based on the essentially linear relationship between heart rate and oxygen uptake relative to work load on a group of young physical education students. From the results, a nomogram was constructed, from which estimated MVO_2 could be calculated within 8% of actual measurements (males). The method was not suitable for older subjects because of the decline in maximal heart rate with age (the original nomogram was based on a maximal heart rate of 195 beats per minute), and subsequently the nomogram was adjusted to account for this factor (10). A number of criticisms have been made regarding the nomogram (45, 92, 125) and alternative techniques have been developed by other investigators in the area (46, 77, 78). The major criticisms have been on the acceptance of the linear relationship between heart rate and oxygen consumption up to maximal levels (45, 78) and the acceptance of a constant efficiency at submaximal work loads (99).

Application of the Astrand-Rhyming nomogram on particular groups (sedentary, trained, athletes) has given varying results compared to the actual measurements of the MVO_2 (92), and the accuracy of the method has varied from different laboratories (45, 58, 92, 106). A number of investigators (45, 106) have compared three different methods of estimating the MVO_2. Davies et al. (45) reported an accuracy within 12 to 15% while Shephard (106) reported an accuracy within 8 to 10% and has strongly recommended the technique if properly applied. Both investigators found the Maritz-Wyndham method (78) to be the most consistent.

The investigations on prediction techniques for estimating the MVO_2 have been of considerable importance. Besides being convenient tests for older individuals, prediction methods are very applicable in field work. Wyndham (125) has recently reviewed the various methods for estimating the MVO_2, with a discussion of some of the advantages over actual methods.

Standardization of prediction tests are important, not only for the particular apparatus used, but also the manner in which the test procedure is carried out. Standardization of procedure is important because of the many factors which may affect the submaximal heart rate, especially at lower work loads. A number of these factors has been reviewed by Taylor et al. (118, 119) and more recently by others (102, 106).

It is generally accepted at present that prediction tests of MVO_2 are the only tests feasible for estimating the aerobic power of large population samples. Studies have recently been completed to determine the best apparatus for estimating MVO_2 in field surveys (99, 102) and

for direct measurements in the laboratory (101). It has been recommended that the treadmill (set at an incline) be used for the direct assessment of MVO_2, and it has been found that the step-test is marginally superior to the bicycle ergometer for predicting MVO_2. Much of the work on standardization has been carried out in conjunction with the IBP (99, 101, 102). There still remains some difficulty in establishing a universally acceptable procedure regarding prediction tests, because of the many independent organizations that are involved in physical fitness research (106). Applying prediction techniques on various populations requires some caution, since the method should be employed only when the relationship between the predicted and actual values are known for the population under study (41).

Studies of Aerobic Capacity on Various Populations

The majority of existing studies on various populations have been criticized on a number of points, particularly when attempts at comparison are made. The major criticisms have been on the inadequate number of subjects, lack of random selection and poor standardization in techniques for measuring aerobic power. A number of studies have not included other accepted parameters of physical fitness, and a number of techniques have not been applied to large samples, covering a wide age range, to assess their validity (40, 41).

The majority of studies have been poorly documented in terms of nutritional status, activity level (including occupational activity), health status and smoking and drinking habits (100). Difficulties are apparent in the exact definition of the amount of activity characteristic

of different groups - whether occupational or recreational. The questionnaire method has proved unsatisfactory (41) and the only available methods to accurately determine the amount of physical activity are by use of a diary, which is time consuming (41), or by estimating energy cost throughout a day by employing portable apparatus for collecting expired air (18, 48, 86).

There has been considerable interest concerning populations which still live a primitive existence, because of their reliance on physical activity for subsistence. Confounding factors, such as nutrition and genetic background must be considered when data on these populations are used for comparison (5, 40). Data on primitive populations is considered important, because some insight may be gained on the work capacities of individuals living 100 years ago, when production was mainly dependent on muscle power.

The first study on a relatively large number of subjects, covering essentially the entire life span 6 to 91 years, was completed by Robinson (90) in 1938. Aerobic power was determined from one maximal run on a treadmill on subjects that were predominantly sedentary. The older subjects stopped running when undue stress was felt and the true MVO_2's in these subjects were probably not reached. Unfortunately the numbers of subjects in the older age categories were small and the subjects were not randomly selected. From the results, Robinson found a decline in MVO_2 with advancing age. The mean values were 43.1 ml./kg./min. for those 30-39 years of age, 39.5 ml./kg./min. for those 40-49, 38.4 ml./kg./min. for the age category 50-59, 34.5 ml./kg./min. for the 60-69 year age group and 25.5 ml./kg./min. for those subjects over 70

years of age. Robinson also observed a corresponding decline in maximal heart rate with age. Many studies have been conducted since on sedentary populations, and despite the difference in methodology, the majority agree closely with the results obtained by Robinson comparing the same age categories (9, 10, 45, 103, 113). The exact reasons for the decline in MVO_2 and maximal heart rate with age have not been definitely established, but a number of factors relating to the cardiorespiratory system are probably involved (9, 113, 114). A number of studies on similar populations have been in variance to the results shown by Robinson and others. Values for MVO_2 were considerably lower for the age groups studied, probably due to the technique used (19, 61) or the inability of the subjects to reach maximal values in one exhaustive run (76).

The Effects of Training on MVO_2 in Older Subjects

Training may only increase the MVO_2 by 10 to 20% (18) since it is evident that natural endowment is the most important factor in determining an individual's maximal. The MVO_2 does not in itself reveal whether or not an individual has been physically active in preceding years (18).

A number of studies have shown that training older subjects substantially increases the MVO_2 (37. 38, 62, 80, 82, 97, 109). The decline in MVO_2 may be partially prevented by regular physical activity (37, 38, 40). In other studies comparisons have been made between physically active and sedentary groups (4, 80) old active athletes and old former athletes (60, 96) and one in which a group of active and sedentary

individuals were tested in 1949 and again in 1964 (67). Each study showed conclusively that regular activity (in varying amounts) maintained or increased aerobic power above the levels apparent in sedentary subjects. Saltin et al. (95) has shown the upper limits of aerobic power from MVO_2 data on international class endurance athletes. Generally these athletes were in the younger age categories, but the study is of interest in indicating the upper limits of endurance fitness.

The amount of training necessary to reach a certain level of aerobic power has been based largely on trial and error until the work of Cooper (37, 38). Cooper analyzed the oxygen cost of various sporting activities and determined the amount of exercise required per week to increase the MVO_2 of the individual. The amount of exercise depended on the age of the individual and the initial level of fitness (aerobic power). Recently, Massie et al. (79) has re-examined the oxygen cost of some of the sporting activities studied by Cooper.

Although training will increase aerobic power, it has still not been determined what beneficial effects this may have on the health of the individual, other than providing an increased sense of well-being (41).

Aerobic Capacity of Primitive Populations

Primitive societies present particular problems when comparisons on different physiological parameters are made because of possible nutritional, climatic and genetic differences. Nevertheless, these populations generally have in common high activity levels, relying more or less on muscular effort for survival (40). Unfortunately the majority

of studies on primitive groups have only been on young subjects (2, 3, 72, 123).

Nomadic Lapps (4) have high aerobic capacities with a mean value of 54 ml./kg./min. for those 30-39 years of age and 44.0 ml./kg./min. for those 50-60 years of age. These values are considerably above the data shown by Robinson and others for comparable age groups. Other studies on primitive populations, involving subjects below the age of 30, have indicated that MVO_2 is higher compared to populations from highly developed countries (2, 72, 123). Exceptions are the Bantu mining recruits studied by Wyndham et al. (122) and the Arctic Eskimos studied by Andersen et al. (3). The study by Anderson (7) on Western Canadian Indians showed MVO_2 values comparable to sedentary Caucasian populations. Although the Canadian Indian has a different genetic background, they have been more or less assimilated into Canadian culture.

It is probable that the higher aerobic capacities of primitive populations reflect higher levels of activity. Although the patterns of living involve strenuous exercise, these activities have not been measured by scientific techniques (5).

Aerobic Capacity of Occupational Groups

Despite the increased mechanization in highly industrialized nations, there remain a number of occupations which demand relatively high levels of physical activity. It would be expected that occupations requiring considerable energy expenditure would more or less train the oxygen transport system and result in higher MVO_2 values compared to more sedentary groups (18). If comparisons were made with other samples,

of if it was desired to gain some insight into the general physical standard of a country, the activity level of various occupational groups would have to be kept in mind. If differences in MVO_2 occurred between the groups studied, it would probably be due to a selection, since those with a strong constitution are over-represented in occupations with physically demanding tasks. If the general level of fitness is desired- it becomes necessary to study large random samples which are difficult to examine successfully (18).

The most successful method of determining the activity level of a particular task has been to analyze the oxygen cost (in K cal./min.) of the task, employing portable equipment to collect expired air (18). Passmore and Durnin (86) and I. Astrand (18) have analyzed the energy cost of various work activities. For agricultural workers (86) the energy expenditure for various activities varied from 1 to 10 K cal./min. Daily rates ranged from 2,450 to 3,550 K cal. I. Astrand found that lumbering activities required the greatest amount of energy expenditure - up to 6,000 K cal./day (18). In further work I. Astrand (18) found that workers free to set their own pace, worked at approximately 40% of the MVO_2. The analyses were made on construction workers 30 - 70 years of age, but the same is probably true for other occupations.

According to Astrand and Rodahl (18) there are wide variations in energy expenditure and the strain of work must be considered in relation to the individual's work capacity and aerobic power. Therefore, peak loads of a task are more important than mean caloric expenditure.

It is evident from the work of Passmore and Durnin (86) that there are various operations involved in farm work. Some of the tasks require

considerable effort, while others do not. Since farming is seasonal, some activities will be more prevalent at different times of the year. If mechanization is not prevalent, farming may be considered hard work, especially in the busy season (18).

For individuals with different occupations there has been a definite trend that the mean MVO_2 values vary to some degree with the nature of the occupation. I. Astrand (18) found the highest predicted MVO_2's in forestry workers and the lowest values for office workers. The age range of the subjects was approximately 20-65 years. In contrast, Andersen (5) found little difference between a group of lumbermen and clerks employed in an office. The age range of this group was 30-59 years. Cumming (40) found no differences in the mean MVO_2's between a sample of men working in a furnace factory and an office for the age group 30-39, but found differences in the age groups 40-49 and 50-59. Little data is available on farm workers alone, however, Ikai et al. (68) included a small sample ranging in age from 16-40 years. The mean MVO_2 was 42.5 ml./kg./min., and the range was 27.4 to 57.2 ml./kg./min. There were only 25 subjects in the sample with a mean age of 28.9 years. Consequently, few of the subjects were in the higher age categories.

Vital Capacity

Vital capacity, measured in liters/min. has been shown to correlate highly with MVO_2 (when expressed in liters/min.) (11, 18), but has no relationship with MVO_2 expressed in ml./kg./min. Shephard et al. (103)

found no relationship between vital capacity and the absolute measure of MVO_2, apparently because other authors have failed to account for size factors to which vital capacity is related.

Vital capacity gradually decreases after the age of 30 (18) and it has been shown (88, 98) that athletes tend to have higher vital capacities compared to more sedentary populations. Nevertheless, it is still controversial whether training induces an increase in this parameter (43). It has been shown that MVO_2 cannot be predicted from vital capacity, but to attain a value of 4.0 liters/min., an individual must have a vital capacity of at least 4.5 liters (18). It has been definitely established that smoking causes a decrease in vital capacity (63, 98), especially in the older age groups. It is considered that vital capacity is probably not a limiting factor in the expression of MVO_2 (43), but the inclusion of this measure in a test battery may yield valuable information regarding the respiratory system (5, 18, 120).

Skinfold Thicknesses and Percent Body Fat

Measures of aerobic power should not be the sole tests utilized in a field survey of physical fitness (5, 40). Anthropometric data, such as the estimation of percent fat has considerable significance since the MVO_2 is usually expressed in ml./kg./min. The overweight individual will be penalized as a result. There remains some uncertainty concerning the manner in which the MVO_2 should be expressed, whether as liters/min., in ml./kg./min., or ml./kg. of lean body mass/min. (40, 41). Expressing the MVO_2 in ml./kg. of lean body mass/min. has value in

theoretical considerations (33, 40, 41), but may not reflect the ability of the individual to move from one point to another.

Numerous studies have been completed on various methods of estimating percent body fat. These methods have included the determination of body density by hydrostatic weighing and the use of various formulae to estimate percent fat (20, 21, 30, 70, 89, 108), whole body counters - ^{40}K (39, 112), and ultra-sound and electrical conductance equipment (24). These methods require expensive apparatus and trained technicians, and are not suitable for field surveys.

An additional method of estimating fatness has been from the use of skinfold calipers (23, 51, 116). Skinfold thicknesses alone have been used to indicate fatness (4, 27, 29, 31, 35, 53, 69, 71, 87, 105, 111) or have been used in conjunction with body density measurements and various formulae to estimate percent body fat (1, 7, 39, 49, 56, 68, 85, 110). At present the skinfold caliper is the most useful apparatus in large surveys (29).

Standardization of skinfold sites and jaw pressure of the particular caliper is important for valid comparisons between populations (29). A number of skinfold calipers have been standardized but methodology has been extremely variable, whether using skinfold thicknesses alone or using the skinfolds to predict percent body fat. Because the methods for predicting percent body fat from skinfolds are so different, it is probably more valid to compare skinfold thicknesses only, at similar sites.

If skinfold thicknesses alone are used, Brozek (29) has recommended that for characterizing the pattern of individual fat distribution, the number of sites should be large, but for classifying individuals along

the leanness-fatness continuum, such as in field surveys, the number of sites should be small. Brozek further stated that the selection of sites involves accessibility, precision in locating the site, homogeniety of the layer of skin and subcutaneous fat and validity as an index of total fatness.

According to Brozek (29) skinfolds are typically skewed to the right, and it has been recommended that skinfold data be expressed in normative form. In contrast Shephard (105) found little skewness in subjects over 30 years of age, presumably because by this age, most individuals display a certain amount of obesity. A number of studies have shown increased fat deposition with age (7, 28, 31, 111), and according to Siri (108) this is true to the age of 55, but little data is available on very old individuals.

The level of physical activity reflects the amount of fat in the body. Studies have shown that athletes and those active in sports have less fat than sedentary individuals, as indicated by skinfold thicknesses (4, 60, 96, 111) or by percent fat (4, 28). Similarly studies have shown that those engaged in physically demanding occupations exhibit less fatness compared to sedentary groups at all age levels (31, 71, 111).

A number of surveys have been carried out to measure skinfold thicknesses or estimate percent body fat in primitive populations (53, 68, 69). It has generally been found that skinfold thicknesses are much less compared to populations in industrialized nations. The relative importance of nutrition, physical activity or genetic constitution and their effects on fat content in these populations, has not been determined.

Hand Grip Strength

It has been found that strength measurements are difficult to standardize and apply in field situations (43). Kroemer (73) and Kroemer and Howard (74, 75) have recently discussed some of the problems in definition of terms concerning strength measurements, the measurement of the types of strength as defined and the calculation and interpretation of data.

Generally, strength decreases from a maximum at age 30 to approximately 70% of the maximum at age 65 (18). Various studies (32, 34, 55, 93) have shown the gradual decrease in hand grip strength with advancing age. Shephard et al. (103) found in a survey of working-class Canadians, that hand grip strength did not vary greatly until after the age of 50. It was also found that there was little difference between the grip strength scores of active and inactive groups in the survey. It has been found in children (40, 43) and in adults (103) that grip strength and other strength measures do not correlate with other parameters of fitness, such as the MVO_2.

CHAPTER III

METHODS AND PROCEDURES

Main Study

Methods for Acquiring the Sample

In order to obtain a large population sample of farmers in rural Manitoba it was decided that a mobile unit would be rented such that all necessary equipment could be carried in the unit as well as serving as the test center. The objective was to obtain information from the Provincial Department of Agriculture as to the times and locations of all agricultural exhibitions in the province during the summer of 1971. The information was obtained from the extension service, Manitoba Department of Agriculture in Winnipeg.

The period between June 11 and July 31 was chosen as the complete test period. The best possible combinations of dates and places were determined in terms of distance and continuity from Winnipeg during this period. This was accomplished by consulting a map of the province.

The next step involved contacting the secretary of the agricultural society from each rural community selected. A letter was sent to each secretary asking permission to attend their fair (Appendix A). Replies were received from all communities, and all were in the affirmative. The following is a list of the fairs attended with their respective dates.

June 11 - 12	Lundar
June 18 - 20	Stonewall
June 22 - 23	Deloraine

June 24 -	Boissevain
June 25 - 26	Killarney
July 2 - 3	Carberry
July 6 - 7	Holland
July 9 - 11	MacGregor
July 12 -	Oak River
July 13 -	Strathclair
July 14 -	Shoal Lake
July 16 - 17	Souris
July 21 - 25	Morris
July 28 - 29	Steinbach
July 30 - 31	St. Pierre

An advertisement sheet was written and sent to the extension division of the Department of Agriculture. The department provided free television, radio and local newspaper advertising of the testing unit and the times and locations.

Testing Unit

The mobile unit consisted of a ford one-half ton truck pulling a twenty foot trailer. The trailer had adequate space for all necessary test equipment and for conducting the various measurements.

Subject Selection and Procedure at Each Fair

This method of obtaining subjects had not been tried before and it

was not certain how many individuals would respond at each community. A large number of subjects was required making it necessary to rely on volunteers. It was decided that choosing a random sample would not be possible. It was hoped that at least four hundred and fifty individuals would volunteer in the project.

Upon arrival at the particular community, the secretary of the Agricultural Society was contacted for instructions on setting up the testing unit on the fair grounds. This occurred on the first day of each fair, or if the exhibition lasted only one day, setting up took place the evening before.

After all apparatus was in working order, individuals from approximately thirty years and over were approached and asked if they would like to take part in the study. Periodically the public address system was utilized to draw attention to all individuals on the fair grounds. A brief account of the tests and the objectives of the study were given.

Finally, a number of humourous posters were displayed around the testing unit to attract attention, but these appeared to be ineffectual. Later, more conservative posters, describing the objectives and characteristics of the study were portrayed, but the effects appeared equally benign.

Periodically, there were a number of free days between fairs, at which time a return was made to Winnipeg to check equipment, correct faults in the unit and tabulate accumulated data.

List of Apparatus

The following is a list of all equipment used in the research unit

during the length of the study.

Monark bicycle ergometer, Collins wet vitalometer, Stoelting hand grip dynamometer, Litton portable electrocardiogram, sphygmomanometer, stethescope, air-conditioner, bi-polar electrocardiograph leads, Harpenden skin-fold calipers, portable bath-room scale - calibrated in pounds, cloth tape-measure - calibrated in inches, emergency kit, nitroglycerine, oscilloscope monitor, stop-watches, mechanical metronome, heart-rate charts, predicted maximal oxygen uptake charts, (Astrand), questionnaire forms, fitness report forms, safety instruction sheets, towels and plastic tape.

Calibration of Major Apparatus

Litton electrocardiogram - The electrocardiogram was thoroughly calibrated by an expert electronics technician at the Childrens' Hospital.

Monark bicycle ergometer - The bicycle ergometer was leveled and the pendulum set to zero. Weights from one to seven kilograms were hung perpendicularly from the movable pendulum. The marker on the pendulum was lined up with the work-load scale by moving the adjustable weight on the pendulum if it was necessary. The bicycle was further calibrated using a device developed by the engineering department at the University of Manitoba (42).

All other equipment was examined and tested before the testing period began, and periodically thereafter.

Testing Procedure

After all equipment was functioning properly, and subjects were available, the volunteers entered the trailer two at a time and were asked to remove shoes, shirt and undershirt. A brief questionnaire (Appendix A) was administered with emphasis being placed on previous or current heart conditions. Height was measured using a cloth tape (inches) attached to a wall of the trailer. Height in inches was converted to the metric system to the nearest centimeter. Weight was measured using a portable bathroom scale calibrated in pounds and converted to kilograms.

Hand Grip Strength

A mechanical Stoelting hand grip dynamometer was employed to measure hand and forearm strength. Subjects were asked to use the dominant hand with two trials being permitted. For the most comfortable grip, the handle of the dynamometer could be adjusted. The subject was instructed to grip the dynamometer and steadily increase the pressure on the handle until the indicator needle could not be moved further. After a few seconds rest, the subject was asked to repeat the test. The subject was not allowed to support his arm in any way or to manipulate the dynamometer by a jerking movement. The highest score was recorded to the nearest kilogram for statistical treatment.

Vital Capacity

A Collins wet vitalometer was utilized for this measurement. The

subject was instructed to breath in as much air as possible and pinch the nostrils with his free hand. The individual was then asked to place the mouth-piece against his teeth and seal the air-way with his lips. The subject was further instructed to steadily force all of the air out of the lungs until the pulley on the vitalometer could not be moved further. This was repeated until two trials had been performed correctly. Most trials were completed after two attempts. Measurements were recorded to the nearest one-tenth of a liter and the largest measurement was recorded for statistical treatment.

Body Fat

Skinfolds were measured and percent body fat calculated after the method described by Durnin and Rahaman (49). Based on the results of the relationship between skinfolds and body density determined by underwater weighing, a number of regression equations were calculated. The regression equation (men) for the estimation of body density (Y) from the log of the sum of four skinfold thicknesses in mm. (X) was:

$$Y = 1.1610 - 0.0632X$$

The four skinfolds were the triceps, biceps, subscapula and suprailiac.

The values determined for body density could then be substituted into the Siri equation (108) to estimate percent body fat. This equation was:

$$\%\ \text{Fat} = [(4.95/\text{density}) - 4.5] \times 100$$

A convenient table (49:688) was constructed such that the sum of the four skinfolds could be directly translated into percent body fat.

All skinfold measurements were taken with the subject standing relaxed and erect. For convenience of handling the skinfold caliper and ease of reading the dial, the tricep and subscapular skinfolds were taken on the left side and the bicep and suprailiac skinfolds on the right side of the body. Measurements were taken twice at each site by the same trained examiner. The average of the two measurements was recorded from each site. The measurement technique consisted of reading the dial when the indicator came to a relative stop after the initial fast movement. The Harpenden skinfold caliper was employed as described by Tanner et al. (116). Measurements were taken at each site by the following method:

Triceps - The caliper was applied over the mid-point of the muscle belly, midway between the olecranon and the tip of the acromion; the upper arm hanging vertically. The jaws of the caliper were placed in the vertical plane.

Subscapular - The caliper was applied just below the tip of the inferior angle of the scapula at an angle approximately forty-five degrees to the vertical.

Biceps - The caliper was applied over the mid-point of the muscle belly with the arm hanging relaxed and vertically. The jaws of the caliper were placed in the vertical plane.

Suprailiac - The caliper was applied just above the iliac crest in the mid-axillary line at an angle approximately forty-five degrees to the vertical.

In all cases the skin and underlying subcutaneous fat was grasped firmly and pulled up and away from the underlying tissues. The caliper jaws were placed approximately three centimeters away from the fingers holding the skinfold.

Six-Minute Bicycle Ergometer Test

This test was performed for the purpose of estimating maximal oxygen uptake. The test consisted of pedalling the bicycle ergometer continuously for six minutes at a constant work load and rate. For reasons of safety and ease of calculating heart rates, an electrocardiogram was employed while the test was in progress. For additional safety, an oscilloscope was used to monitor the cardiac cycle continuously.

The subject was instructed to sit on the bicycle ergometer after which the saddle was adjusted according to the individual's height. This allowed the leg to be almost fully extended when the pedal was in the lowest position.

Good electrocardiograph records were necessary and for this purpose three light weight exercise leads were utilized. Each lead consisted of a plastic cup containing a silver electrode disc. These were attached to long flexible wires which in turn connected to the electrocardiogram apparatus.

The subject was prepared by rubbing the skin thoroughly with an alcohol swab at the points where the leads would be attached. This removed the surface horny layer of skin and reduced electrical resistance. An electrolyte paste was applied to each cup to further reduce electrical resistance. The exploring lead was applied to the V-5 position or just

below and to the left of the apex of the heart in the mid-axial line. The ground lead was placed in a similar position on the right side of the chest. The indifferent lead was placed over the superior end of the manubrium or over the clavicle proximal to the manubrium. This avoided muscle tremor which could interfere with the cardiograph tracing. Occasionally, a great deal of chest hair was present on a particular individual making it necessary to place the indifferent lead on the forehead. The leads were held in place by plastic tape. Finally, the oscilloscope was synchronized with the electrocardiogram for continuous monitoring of the cardiac cycle.

The subject was asked to pedal the bicycle ergometer at a frequency of fifty revolutions per minute. A mechanical metronome helped the subject maintain the cadence. A mechanical revolution counter was connected near the drive sprocket to monitor the number of revolutions accomplished in six minutes. This facilitated the calculation of the exact amount of work performed during the test, since

$$\text{work performed} = \frac{\text{force(load setting)x distance(revolutions x wheel circumference)}}{\text{time (in minutes)}}$$

The work accomplished was calculated simply by multiplying the load setting times the number of revolutions in the six minute period.

Work loads were chosen to ellicit a heart rate approximately seventy percent of the maximal heart rate for each age group (ten year range). This ideal heart rate for each age group was allowed to vary $\pm$ five beats per minute. If a particular heart rate was too high or too low, the load setting was adjusted accordingly. This adjustment was taken into account when calculating the amount of work performed.

Work loads were selected to attain the required heart rates by the following method:

Age Groups	Work Loads	Heart Rates
30 - 40	900	170
40 - 50	750 - 900	160
50 - 60	600 - 750	150
60 and over	300 - 450 or 600	140

The above chart acted as a rough guide for the determination of the required work load and heart rate.

Safety

The testing unit was at no time in close proximity to a hospital. This necessarily required certain precautions, particularly when subjects past the age of fifty years were performing the bicycle ergometer test. The author was given particular instructions to watch for changes in the electrocardiograph tracings and the oscilloscope. The subject was asked to stop pedalling if the tracing showed an S-T depression of more than two millimeters or if there were frequent extra-ventricular systoles. If the subject experienced difficulty in breathing or complained of chest pains, the test was to be immediately stopped. Subjects who had abnormal resting electrocardiogram's were exercised at a reduced work load with heart rates ten to twenty beats per minute below the required level.

Normally, individuals with known heart disease were not allowed to take the bicycle ergometer test. A few individuals insisted on trying

the test and if it was not busy, were permitted to do so. The work load was kept at 0 kpm or 150 kpm and close watch was kept on the electrocardiograph tracing.

A first-aid kit was available in case of emergency. The kit contained an air-way and a resuscitator to administer air to a subject if it were required. Nitroglycerine tablets were also available. One of these tablets was to be given to an individual if chest pains persisted for more than two minutes. The author was also instructed on how to perform external heart massage. At no time was it necessary to perform any of these procedures.

Heart rates were recorded at rest and every two minutes during the work test, and a recovery heart rate was taken two minutes after the work test was completed.

Fitness Report

A brief fitness report (Appendix A) was given to each individual upon completion of all of the test items. Each item on the report was explained to the subject and how the subjects performance compared with the average for his age group.

Secondary Study

Description of the Secondary Study

In April of 1969, the agricultural representative for the Rural Municipality of Hamiota, in the province of Manitoba, was approached by the author to obtain volunteers from the local farm population to

participate in a study requiring a maximal performance on a bicycle ergometer. Time did not permit a random selection of subjects. All volunteers were examined by a cardiologist before testing began. At the same time, preliminary measurements were taken, including height and weight, vital capacity, grip strength and skinfolds. Each volunteer was given a time to appear for the maximal bicycle ergometer test. The maximal tests were carried out in the local hospital. All volunteers in the study were asked to sign their questionnaire form consenting to take part in the maximal exercise test.

List of Apparatus for Measuring Maximal Oxygen Uptake

The following is a list of all apparatus used to carry out the maximal test, and to measure and calculate maximal oxygen consumption.

Monark bicycle ergometer, Beckman paramagnetic oxygen analyzer, Beckman LB-1 carbon dioxide analyzer, calibrated tanks of CO_2 and O_2, dry-test spirometer manufactured by the American Meter Company, Collins gas pump, drierite, soda lime for carbon dioxide absorption, meteorological balloons for expired air collection, Sanborn portable electrocardiogram, bi-polar (disc type) exercise leads, electrolyte jelly, alcohol swabs, stop-watches, plastic tape, nose clips, mouth pieces, three-way valves, barometer, centigrade thermometer, nomogram to reduce air volume to STPD and towels.

Calibration of Apparatus

Bicycle ergometer - The bicycle ergometer was calibrated using kilogram

weights and a mechanical calibrator as described previously.

CO_2 and O_2 tanks - Small tanks of CO_2 and O_2 were analyzed by a trained technician.

Beckman LB-1 CO_2 analyzer - The analyzer was calibrated each day before testing began and periodically throughout each testing session. A known amount of CO_2 determined previously by a trained technician was used for the calibration.

Beckman O_2 analyzer - The oxygen analyzer was calibrated in the same manner as the CO_2 analyzer using a known percentage of oxygen.

The remaining equipment was thoroughly examined at the laboratory in Winnipeg before the test session began, to ensure proper functioning. This applied as well to the apparatus used in the preliminary examination, described in previous sections.

Laboratory Conditions

A room with adequate space was provided at the community hospital to carry out the exercise tests. The room was not temperature controlled and was kept reasonably cool by opening windows. Similarly, the humidity was not controlled. Barometric pressure and temperature were recorded periodically throughout the test period each day.

Maximal Exercise Test

The subject was seated on the bicycle ergometer and connected to the electrocardiogram in the same manner described in previous sections.

The work test was continuous, lasting for fifteen minutes. The first two work loads lasted six minutes each; the respective loads remaining constant. Work loads were chosen which would produce a heart rate between 120 and 130 beats for younger subjects and a heart rate approximately 10 beats lower per minute for older subjects. The second work load was chosen to produce a heart rate between 160 and 170 beats per minute for the younger subjects and a heart rate between 140 and 150 beats per minute for older individuals. The maximal work load was performed immediately, lasting for three minutes. This work load was usually 300 kpm more than the second work load value, but for some of the older subjects the load was increased by only 150 kpm. A small percentage of the younger subjects were able to accommodate work loads 450 to 600 kpm higher than the second work load. All of the subjects were motivated in the same way to complete the test. Heart rates were recorded at rest, and every two minutes during the submaximal phase of the test. Final heart rates were taken during the last fifteen seconds of the maximal work load and three minutes after the test was completed.

Expired air was collected between the second and third minute of the final work load. The air was collected in one balloon for thirty seconds and into a second for the final thirty seconds. The expired air in the balloons was then analyzed for CO_2 and O_2 content and volume.

Oxygen Uptake Analysis

The expired air was analyzed soon after the exercise leads were removed from the subject and it was ensured that the individual was

feeling all right. The percentage of carbon dioxide was measured first and recorded. A small sample of the air was pumped through a column of drierite to absorb any water vapour present. A small sample was then pumped through a column of soda lime to absorb the carbon dioxide present and thence through the oxygen analyzer. This procedure lasted for a few seconds to allow the analyzer to react to the sample of air. The percentage of oxygen was measured and recorded. Finally, the air sample was pumped through a gasometer to measure the volume in litres. Using temperature and barometric pressure, the expired air volume was reduced to STPD by determining the correction factor from a nomogram. The same procedure was repeated with the second sample of expired air.

The values for percent carbon dioxide were used as recorded but the values for percent oxygen were corrected on a graph. This procedure involved plotting the known and recorded values of percent oxygen in room air and the calibration gas onto a graph. The actual values were plotted on the abscissa and the observed values were plotted on the ordinate. The observed percent oxygen from each sample of expired air was then corrected to the actual value. New graphs were constructed to account for changes in observed values when the calibration gas and room air were pumped through the oxygen analyzer. This procedure was carried out at least twice a day. The appropriate calculations were subsequently made to determine the maximal oxygen consumption of each subject.

Statistical Analysis

A computer program (Appendix B) was developed for the Olivetti

Programma 101 to estimate oxygen uptake values from heart rate and work load after the methods of Astrand and Rhyming (12) and Astrand (10) for the main and secondary studies.

A one-way analysis of variance and Newman-Keuls comparisons between ordered means were calculated between nine five-year age groups on fifteen parameters in the main study, employing the computer facilities at the University of Alberta.

A correlation matrix was calculated between the fifteen parameters in the main study (all age groups combined).

A correlation coefficient was determined between the actual and estimated MVO_2's from the secondary study (all age groups combined), using the Olivetti Programma 101.

A t-test was computed between the actual and estimated MVO_2 values determined in the secondary study, using the Olivetti Programma 101.

CHAPTER IV

RESULTS AND DISCUSSION

Characteristics of the Subjects

Main Study

A total of three hundred and twelve subjects throughout rural Manitoba participated voluntarily in the main study. The age range of the subjects was 30 - 85 years. The physical characteristics of the subjects from this study are presented in table I by five year age groups.

TABLE I

PHYSICAL CHARACTERISTICS OF THE SUBJECTS BY AGE GROUPS

MAIN STUDY

Age Group	Mean Age	N	Mean Height (CM.)	Mean Weight (KG.)
30-34	32.0	25	179.2	80.1
35-39	37.3	44	176.9	85.4
40-44	41.6	50	175.9	81.5
45-49	46.8	43	175.2	81.0
50-54	52.2	58	177.1	79.3
55-59	56.9	43	175.4	78.6
60-64	62.1	19	164.3	75.1
65-69	66.7	19	172.4	75.9
70- +	74.2	11	174.2	72.9
Overall	48.9	312	175.4	80.0

Secondary Study

In the secondary study, forty seven subjects volunteered to participate in the fitness tests. All of the subjects were from one rural municipality in Manitoba, actively engaged in farming. The age range

of the subjects was 30 - 69 years. The physical characteristics of these individuals are listed in table II.

TABLE II

PHYSICAL CHARACTERISTICS OF THE SUBJECTS BY AGE GROUPS

SECONDARY STUDY

Age Group	Mean Age	N	Mean Height (CM.)	Mean Weight (KG.)
30-34	33.3	3	181.0	84.3
35-39	37.7	11	175.9	80.8
40-44	41.3	11	180.3	83.3
45-49	46.6	10	176.1	78.6
50-54	51.7	3	174.7	80.8
55-59	56.6	5	177.5	77.9
60-64	62.0	3	170.5	79.0
65-69	69.0	1	163.8	66.6
70- +	-	-	-	-
Overall	45.3	47	176.8	80.4

Questionnaire Results

Main Study

The results of the questionnaire (Appendix A) administered to the subjects were not statistically analyzed, but a number of general conclusions were made.

Although eating habits were not included in the questionnaire, it is assumed that the majority of subjects enjoyed a more than adequate diet. Drinking habits were not explored and it is assumed that the majority of the subjects occasionally consumed alcohol.

A surprising number of subjects did not smoke, having stopped recently or for some time. The majority of those who did smoke, did not

consume over 10 - 15 cigarettes per day.

From the answers given, most of the subjects were free from any health problems at the time of testing, other than slight colds etc. in a few. Those subjects who had had heart attacks in the past or were suffering from any current heart problems, were, in most cases, not allowed to participate in the bicycle ergometer test. Few subjects were rejected for this reason.

The younger subjects were actively engaged in farming - mostly mixed farming; livestock and grain being the major produce. A few subjects were strictly grain farmers and many of the older subjects had retired from farming. The major recreational activity was curling during the winter months and a few of the younger subjects played hockey in winter, and baseball or fastball in the summer. A number of subjects from all age groups played golf during the summer. Generally, vigourous recreational activities were not evident during the summer months.

Food consumption prior to testing varied considerably in amount, and the length of time before the tests. A few subjects had consumed alcoholic beverages prior to participating in the tests.

A small number of subjects from urban centers were allowed to participate in the tests when it was not busy, and the results were included in the study.

Secondary Study

The same general characteristics regarding nutrition, activity levels and smoking and drinking habits were apparent, concerning the subjects in the secondary study. All of the subjects, however, were

actively engaged in farming and all resided in the same municipality. Each subject was examined by a cardiologist before testing, to ensure that the subject could safely perform the maximal test. Six subjects were unable to complete the maximal work test and one subject was unable to complete the submaximal phase of the bicycle ergometer test.

The Maximal Oxygen Uptake

Main and Secondary Studies

One-way analyses of variance and Newman-Keuls comparisons between ordered means were conducted on submaximal work loads, submaximal heart rates and estimated MVO_2's between five year age groups on the data from the main study. These analyses appear in Appendix C, table XVI.

The means and standard deviations for the submaximal work loads, submaximal heart rates and resulting estimated MVO_2's for each five year age group, are presented in table III (main study) and table IV (secondary study). A graphic representation of the estimated MVO_2's by age groups for both studies, is seen in figure I. In the second study, one subject was unable to complete the submaximal phase of the bicycle ergometer test, making the total number of subjects 46.

The results of the means and standard deviations of the observed MVO_2's and maximal heart rates from the secondary study are listed in table V by five year age groups. The total sample included 41 subjects, since six of the volunteers were unable to complete the maximal bicycle ergometer test. The MVO_2 results, by age groups, are seen graphically in figure I.

TABLE III

MEANS AND STANDARD DEVIATIONS OF SUBMAXIMAL WORK LOADS, SUBMAXIMAL WORK HEART RATES AND ESTIMATED MVO_2's BY AGE GROUPS

MAIN STUDY

Age Group	N	Work Load (Kpm/Min.)	Work Heart Rate (Beats/Min.)	Estimated MVO_2 (Ml./Kg./Min.)
30-34	25	964.4 (116.7)	159.9 (12.1)	38.4 (5.7)
35-39	44	896.6 (135.2)	149.7 (13.9)	33.5 (6.2)
40-44	50	874.9 (111.9)	153.1 (11.6)	31.3 (6.3)
45-49	43	817.2 (149.2)	146.4 (15.0)	30.0 (5.9)
50-54	58	749.0 (132.2)	140.2 (11.5)	29.2 (5.8)
55-59	43	634.9 (135.1)	133.4 (12.7)	26.1 (5.7)
60-64	19	596.1 (139.5)	134.4 (15.4)	24.7 (7.9)
65-69	19	578.1 (96.8)	127.0 (14.7)	25.6 (8.1)
70- +	11	513.9 (124.9)	122.9 (14.5)	23.3 (4.4)
Overall	312	772.9 (180.8)	143.3 (16.2)	29.8 (7.2)

TABLE IV

MEANS AND STANDARD DEVIATIONS OF SUBMAXIMAL WORK LOADS, SUBMAXIMAL WORK HEART RATES AND ESTIMATED MVO_2's BY AGE GROUPS

SECONDARY STUDY

Age Group	N	Work Load (Kpm/Min.)	Work Heart Rate (Beats/Min.)	Estimated MVO_2 (Ml./Kg./Min.)
30-34	3	881.0 (90.4)	166.3 (4.0)	31.2 (1.6)
35-39	11	987.1 (98.4)	155.7 (6.9)	35.9 (5.4)
40-44	11	965.4 (128.3)	155.2 (11.6)	33.4 (7.4)
45-49	10	892.8 (112.4)	153.1 (9.4)	31.0 (6.1)
50-54	3	1029.3 (160.2)	142.7 (7.7)	37.0 (5.9)
55-59	4	884.3 (145.7)	148.5 (15.7)	29.2 (3.3)
60-64	3	787.0 (136.9)	137.0 (9.6)	28.6 (2.5)
65-69	1	695.0 -	146.0 -	25.3 -
70- +		-	-	-
Overall	46	928.9 (138.5)	152.8 (11.7)	32.9 (6.5)

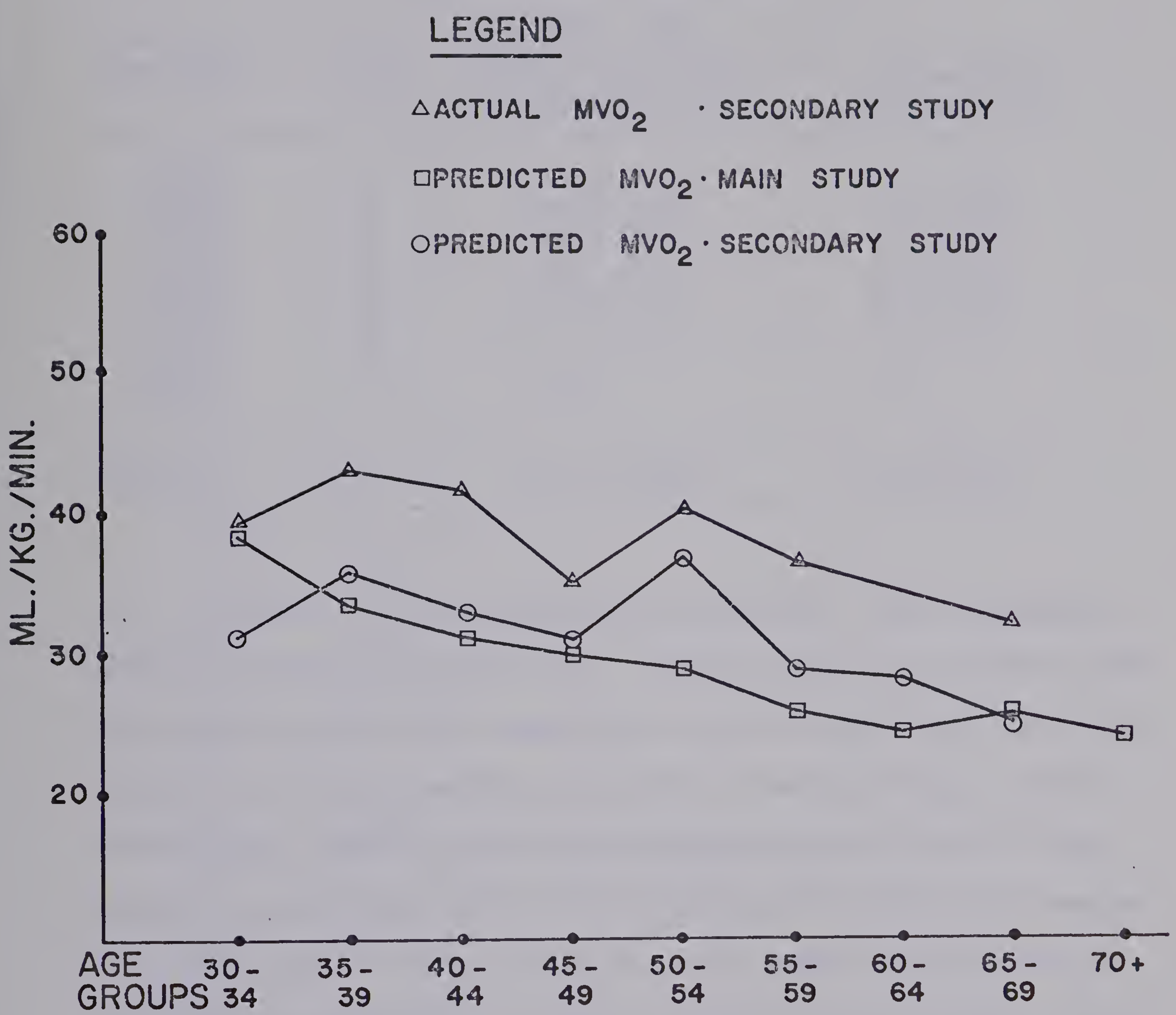

Fig. I MVO_2 IN ML./KG./MIN.-MAIN AND SECONDARY STUDIES-BY AGE GROUPS

TABLE V

MEANS AND STANDARD DEVIATIONS OF MAXIMAL HEART RATES AND ACTUAL MVO_2's BY AGE GROUPS

SECONDARY STUDY

Age Group	N	Maximal Heart Rate (Beats/Min.)	Actual MVO_2 (Ml./Kg./Min.)
30-34	2	194.0 (6.0)	39.4 (3.6)
35-39	11	186.6 (9.9)	43.0 (7.2)
40-44	10	185.1 (7.3)	41.9 (6.3)
45-49	10	176.7 (11.6)	35.0 (7.3)
50-54	3	175.0 (5.7)	40.3 (6.4)
55-59	4	175.8 (6.3)	35.8 (2.7)
60-64	0	-	-
65-69	1	163.0 -	32.1 -
70- +	-	-	-
Overall	41	181.7 (10.9)	39.5 (7.3)

The results from the three tables and figure I show the expected decline in relative MVO_2 with age. Although particular submaximal work loads were pre-determined, depending on age and target heart rate (see Chapter III) for each subject, the amount of work performed, and the corresponding submaximal heart rate depended upon the ability of the subject to maintain the pace of the metronome, determined at 50 revolutions per minute. In other words, the exact number of revolutions of the pedals was determined for the six minutes of work performed, allowing a reasonably precise calculation of the work accomplished. Therefore, as age increased, the work performed and the corresponding submaximal heart rates decreased.

A further simple analysis was made comparing the estimated and observed MVO_2's from the two studies, and the results appear in table VI.

TABLE VI

COMPARISON OF THE MEAN ESTIMATED MVO_2's OF THE MAIN STUDY WITH THE MEAN ESTIMATED AND ACTUAL MVO_2's OF THE SECONDARY STUDY BY AGE GROUPS

Age Group	Main Study Est. MVO_2 (Ml./Kg./Min.)	Secondary Study Est. MVO_2 (Ml./Kg./Min.)	Secondary Study Actual MVO_2 (Ml./Kg./Min.)	% Diff. Secondary Est. vs. Main Est.	% Diff. Actual vs. Secondary	% Diff. Actual vs. Main
30-34	38.4	31.2	39.5	18.8	20.8	2.5
35-39	33.5	35.9	43.0	6.7	16.5	22.1
40-44	31.3	33.4	41.9	6.3	20.3	25.3
45-49	30.0	31.0	35.0	3.2	11.4	14.3
50-54	29.2	37.0	40.3	21.0	8.2	27.6
55-59	26.1	29.2	35.8	10.6	18.4	27.1
60-64	24.7	28.6	-	13.6	-	-
65-69	25.6	25.9	32.1	1.2	19.3	20.2
70- +	23.3	-	-	-	-	-
Overall	29.8	32.9	39.5*	9.4	16.5	24.4

* Difference between overall actual and estimated MVO_2 (secondary study) significant at the 0.01 level.

The results of a t-test between the means of the estimated and actual MVO_2's (all subjects combined) from the secondary study, showed a significant difference at the 0.01 level.

Comparing the total samples from both studies, the mean estimated MVO_2 from the secondary study was 9.4% greater than the mean estimated MVO_2 from the main study. The mean actual MVO_2 from the secondary study was 16.5% greater than the mean estimated from the same study, and 24.4% greater than the mean estimated MVO_2 from the main study.

The estimated MVO_2's from the main and secondary studies were corrected for age, based on age category (18:620). Other correction factors may be used (18:620), based on maximal heart rate. To illustrate if there may be a difference in using the two methods of correction, the mean maximal heart rate for each age group in the secondary study was used as the basis for correcting each subject's MVO_2. This determination raised the overall mean MVO_2 to 35.2 ml./kg./min. The difference between the mean estimated MVO_2 for the entire group and the overall observed MVO_2 (secondary study) became 10.9%.

Discussion

The decline in MVO_2 with age is in agreement with data from the literature. The exact reasons for the decrease in MVO_2 have not been defined, but is due, at least in part, to the decline in maximal heart rate (for which there is no compensatory increase in stroke volume and cardiac output (9, 113, 114). Therefore, the amount of oxygen that can be delivered to the working muscles is reduced. I. Astrand et al. (9) proposed that maximal heart rate declines with age because the older

individual is unable to fully tax the heart, due to failure of the working skeletal muscles. However, it was further pointed out that in the subjects examined, the blood lactate levels were high, indicating that anaerobic processes played a significant role in delivering energy. This indicated that the muscles were working hard enough to stimulate the heart to beat as rapidly as possible. Additional proof was evident when the addition of an extra work load on the maximal work loads performed by the subjects, failed to increase maximal heart rates further. Strandell (113, 114) showed that in older subjects (60 years and over), the limiting factors in maximal working capacity were related more to peripheral factors; either circulatory, muscular or metabolic, rather than the central circulation or the pulmonary function. The decreased functional capacity of any one of these factors probably has a direct effect on the decrease in MVO_2 with advancing age.

Various techniques have been used to estimate the MVO_2, either by use of a nomogram (12, 77) or the Maritz-Wyndham extrapolation technique (78). Each of the methods is based on the linear relationship between heart rate and oxygen consumption or equivalent work load over the range 50 to 90% of aerobic power. The submaximal measurements of these variables are extrapolated to the individual's known or anticipated maximal pulse rate to estimate the MVO_2. The Astrand-Rhyming nomogram (12) is based on one pair of observations, the Margaria nomogram (77) is based on two pairs, and the Maritz-Wyndham extrapolation (78) is based on four pairs of observations. Davies et al. (45) and Shephard (106) have compared the three methods and have found differences in accuracy between the estimation procedures and actual methods of determining MVO_2.

Davies et al. used a wide age range of sedentary subjects and found an approximate 12% underestimation (all three estimation methods) from observed MVO_2 values. Shephard found a 10% underestimation between the three estimation techniques and observed values, and stated that (106: 455-456) at least a quarter of the discrepancy is due to errors in direct measurement, leaving a residual coefficient of variation of 7-8%. Therefore, if estimation techniques are employed under suitably controlled environmental conditions, the standard deviation of the discrepancy between estimated and directly measured values may be reduced to approximately 8%.

Other investigators have found differing results employing the Astrand-Rhyming nomogram. Glassford et al. (58) found good agreement between estimated and observed MVO_2's (measured on a treadmill) on young moderately trained subjects. Luft et al. (76) found that the nomogram slightly overestimated the observed values, measured by employing a bicycle ergometer. The subjects were 27 - 44 years of age and were relatively sedentary. Apparently the subjects did not reach maximal values for oxygen uptake because of the low mean observed value. Rowell et al. (92) found a very large discrepancy (27%) between estimated and actual MVO_2's on a group of young sedentary subjects. This discrepancy was reduced by one-half after a training program. Most of the subjects in the foregoing studies were under 35 years of age, and no correction factor was required to reduce the estimated MVO_2 because of age. It is assumed that a correction factor was used on subjects over 35 years of age. The differences in results from each study are large, including results comparing similar subjects. The reasons are not readily apparent.

In the present study, large differences were apparent between the estimated MVO_2's of the main and secondary studies compared to the observed MVO_2's of the secondary study. One particular reason for the large differences may be in assuming the correction factors for age developed by Astrand (10) to be applicable to all types of individual. When the maximal heart rate for the population under study is unknown, a correction factor based on age groups is used, which may reduce estimated MVO_2's too severely. This particular method of accounting for decrease in maximal heart rate and consequently of estimated MVO_2 with age, was employed in the present study (main and secondary studies). From the results, however, employing the mean maximal heart rate for each age group to correct the estimated MVO_2 reduced the discrepancy between estimated and observed values from 16% to 10.9%. If the estimated results were increased by 8% as proposed by Shephard (100), there would be little difference between the observed and estimated MVO_2's in the secondary study. The number of subjects in each age category from the secondary study was small, therefore, the mean maximal heart rates could not be used as the basis for a correction factor for estimating MVO_2 in other samples.

Other factors must be considered when comparing estimated and observed MVO_2's. These are non-specific factors such as anxiety etc. which may affect submaximal heart rate and consequently the calculation of the estimated MVO_2 (118). The major factor affecting the underestimation of MVO_2 is the non-linearity of heart rate against oxygen consumption at near maximal efforts, which may occur quite independently of age (45). It has been shown that training will alter the heart rate -

oxygen consumption curve, and thus reduce the underestimation of MVO_2 (45, 92).

Comparison of MVO_2 Results with Data From the Literature

A number of limitations were outlined previously (Chapter I - limitations, Chapter II), which must be taken into consideration when comparing data from different laboratories. The MVO_2 results (actual and estimated) and maximal heart rates (where applicable) from the literature are listed in table VII. Studies in which the age groups were arranged by decades, i.e. 30-39, 40-49, are included on sedentary populations, active and trained groups, and ethnic and occupational groups.

TABLE VII

COMPARISON OF MEAN MVO_2's AND MAXIMAL HEART RATES FROM THIS STUDY WITH DATA FROM THE LITERATURE - BY AGE GROUPS

Author and Subjects	Age Range MVO_2 in ml./kg./min. and Maximal Heart Rate 30-39	40-49	50-59	60-69	70-79
Relatively Sedentary Subjects					
Astrand (9)°				(n=9) 30.1 163.0	
Astrand (10)°	(n=13) 39.8 181.0	(n=9) 39.2 173.0	(n=66) 33.1 161.0	(n=8) 31.4 159.0	
Davies (45)°	(n=38) 43.7 36.6* 188.1	(n=20) 37.8 28.5* 181.9			
Hanson (61)°°	(n=25) 37.0 175.0	(n=15) 36.9 168.0			

Author and Subjects	Age Range MVO_2 in ml./kg./min. and Maximal Heart Rate 30-39	40-49	50-59	60-69	70-79
Luft (76)°	(n=65) 32.1 34.1* -				
Robinson (90)°°	(n=10) 43.1 189.0	(n=10) 39.5 179.0	(n=9) 38.4 170.0	(n=8) 34.5 163.0	(n=3) 25.5 158.0
Shephard (100) Untrained Subjects	(n=784) 38.7 -	(n=690) 36.3 -	(n=406) 32.7 -	(n=196) 25.5 -	(n=28) 20.9 -
Shephard (103)°°°	(n=17) 39.8* -	(n=17) 36.4* -	(n=17) 31.5* -	(n=3) 27.4* -	
Strandell (113)°				(n=14) 29.9 -	(n=13) 23.3 -
<u>Trained and Athletic Groups</u>					
Andersen (4)° Skiers			(n=63) 48.0 164.0		
Industrial workers Active			(n=21) 34.0 164.0		
Office workers Sedentary			(n=17) 36.0 177.0		
Grimby (60)° Active old athletes		(n=14) 55.0 175.0	(n=15) 49.8 176.0	(n=4) 41.4 165.0	
Hartley (62)° Before training			(n=15) 35.5 182.0		
After training			40.5 176.0		
McDonough (80)°° Sedentary		(n=15) 36.8 185.0	(n=7) 33.1 180.0	(n=5) 29.4 174.0	

Author and Subjects	Age Range MVO$_2$ in ml./kg./min. and Maximal Heart Rate 30-39	40-49	50-59	60-69	70-79
Active		(n=19) 40.9 176.0	(n=32) 37.6 171.0	(n=7) 32.9 164.0	
Naughton (82)°° Before training		(n=18) 31.3 -			
After training		36.8 -			
Saltin (96)° Former old athletes		(n=10) 44.0 182.0	(n=14) 37.5 175.0	(n=5) 37.0 170.0	
Shephard (100) Active subjects	(n=151) 58.2 -	(n=6) 51.3 -	(n=6) 47.1 -	(n=36) 25.0 -	(n=23) 23.3 -
<u>Ethnic and Occupational Groups</u>					
Andersen (5)° Nomadic Lapps	(n=16) 54.0 -		(n=6) 44.0 -		
Lumbermen	(n=?) 46.0 -	(n=?) 44.0 -	(n=?) 39.0 -		
Industry	(n=?) 44.0 -	(n=?) 38.0 -	(n=?) 34.0 -		
Office	(n=?) 42.0 -	(n=?) 39.0 -	(n=?) 36.0 -		
Anderson (7)° Canadian Indians	(n=60) 44.6**	(n=54) 36.7**	(n=22) 32.3**	(n=20) 26.9**	
Astrand (8)° Truck drivers			(n=67) 32.4 159.5	(n=5) 31.9 158.0	
Cumming (40)° Industry	(n=?) 38.0 -	(n=?) 38.0 -	(n=?) 36.0 -		

Author and Subjects	Age Range MVO2 in ml./kg./min. and Maximal Heart Rate 30-39	40-49	50-59	60-69	70-79
Office	(n=?) 38.0	(n=?) 33.0	(n=?) 31.0		
Ekblom (52)° Easter Islanders	(n=22) 42.1 -	(n=21) 36.0 -	(n=12) 31.0 -		
Ikai (68)° Ainu and Japanese - Various occupations	(n=27) 41.6 -	(n=6) 36.9 -	(n=1) 39.9 -		
Farmers	(n=25) 42.5*** 190.0				
Fishermen		(n=13) 38.6 180.0			
This Study° Main study Rural population	(n=69) 36.0* -	(n=93) 30.7* -	(n=101) 27.7* -	(n=38) 25.2* -	(n=11) 23.3* -
Secondary Study° Rural population	(n=14) 41.2 33.6* 190.3	(n=21) 39.0 32.2* 180.9	(n=7) 38.1 33.1* 175.4	(n=4) 32.1 27.0* 163.0	

* Estimated results - after the method of Astrand (10).

** Estimated results - Astrand (10) and increased 8% according to Shephard (100).

*** Age range - 16 - 40 years.

<u>Methods</u>

° Bicycle ergometer

°° Treadmill

°°° Step-test

Comparison with Estimated MVO_2's From the Main Study

The results for each age group from the main study do not compare well with the data listed in table VII. The mean estimated MVO_2's for each age group are considerably below the respective values on other populations, including sedentary populations.

Comparison with Estimated MVO_2's From the Secondary Study

The observed mean MVO_2's for each age group from the secondary study compare favourably with the data listed in table VII, except for the active and athletic groups. Generally, the actual MVO_2's are greater than the values for sedentary populations (each age group), and similar to the values for other occupational groups. The superiority of the active old athletes (60), older former athletes (96) and the active and athletic groups from Shephards data (100) is apparent, when compared to the rest of the data (for each age category). The nomadic Lapps examined by Andersen (5) are considerably superior to other ethnic and occupational groups, including the farm population from the present study (secondary study - observed values). Surprizingly, lumbermen (5) do not have MVO_2's much superior to other groups. The observed MVO_2's from the secondary study (each age group) are greater than the respective values from the data collected by Shephard (100) on sedentary populations, but below the values for active and athletic groups.

Discussion

The estimated MVO_2's from the main and secondary studies are below

the values determined on other occupational groups. A number of reasons for the low values were discussed previously. The observed values from the secondary study compared well with data on other occupational groups, and in general, were greater than the mean values for sedentary populations for each age group.

It is possible that physical labour will train the oxygen transport system (18); the amount depending on the physical demands of a particular activity. If this is true, the lumberman (5) should have a high aerobic power because of the physical demands inherent in this occupation. However, Andersen's data showed that the lumberman is very little superior to men in industry or those engaged in office work. The observed MVO_2's from the present study compare well with those determined on the lumbermen. The nomadic Lapps apparently lead very active lives, and the MVO_2 results are more indicative for this group. Conclusions cannot be drawn easily regarding the effects of activity levels, because activity levels are difficult to gauge and because of the difficulties in comparing results from different laboratories. From the observed data from the present study, it appears that farming activities may have some direct effect on the aerobic power.

The superior aerobic power of old active athletes is evident, and the effects of training programs may be more easily followed than the everyday occupational pursuits of various groups. Although it appears that the modern farmer has a slightly superior aerobic power over sedentary groups, the differences are not striking, judging from the available data in the present study. The individual engaged in farming may be more willing to work at maximal loads, since he is accustomed,

occasionally, to strenuous work, in contrast to the sedentary individual. This difference may appear in MVO_2 results.

The advantages of mechanization in the farming industry, as well as in others, may well be a disadvantage in terms of the health and physical well-being of the particular individual. The relative contribution of physical activity to health and well being has yet to be determined on a scientific basis.

Vital Capacity - Main Study

A one-way analysis of variance and a Newman-Keuls comparison between ordered means was computed between age groups on the vital capacity data, and the results appear in Appendix C, table XVII.

The means and standard deviations for vital capacity are given in table VIII by five year age groups. The results may be seen graphically in figure II.

TABLE VIII

MEANS AND STANDARD DEVIATIONS OF VITAL CAPACITY BY AGE GROUPS

MAIN STUDY

Age Group	N	Vital Capacity (Liters)	Standard Deviations
30-34	25	4.6	0.51
35-39	44	4.4	0.95
40-44	50	4.3	0.60
45-49	43	4.2	0.66
50-54	58	4.2	0.73
55-59	43	3.8	0.89
60-64	19	3.7	0.61
65-69	19	3.7	0.79
70- +	11	3.3	0.63
Overall	312	4.1	0.79

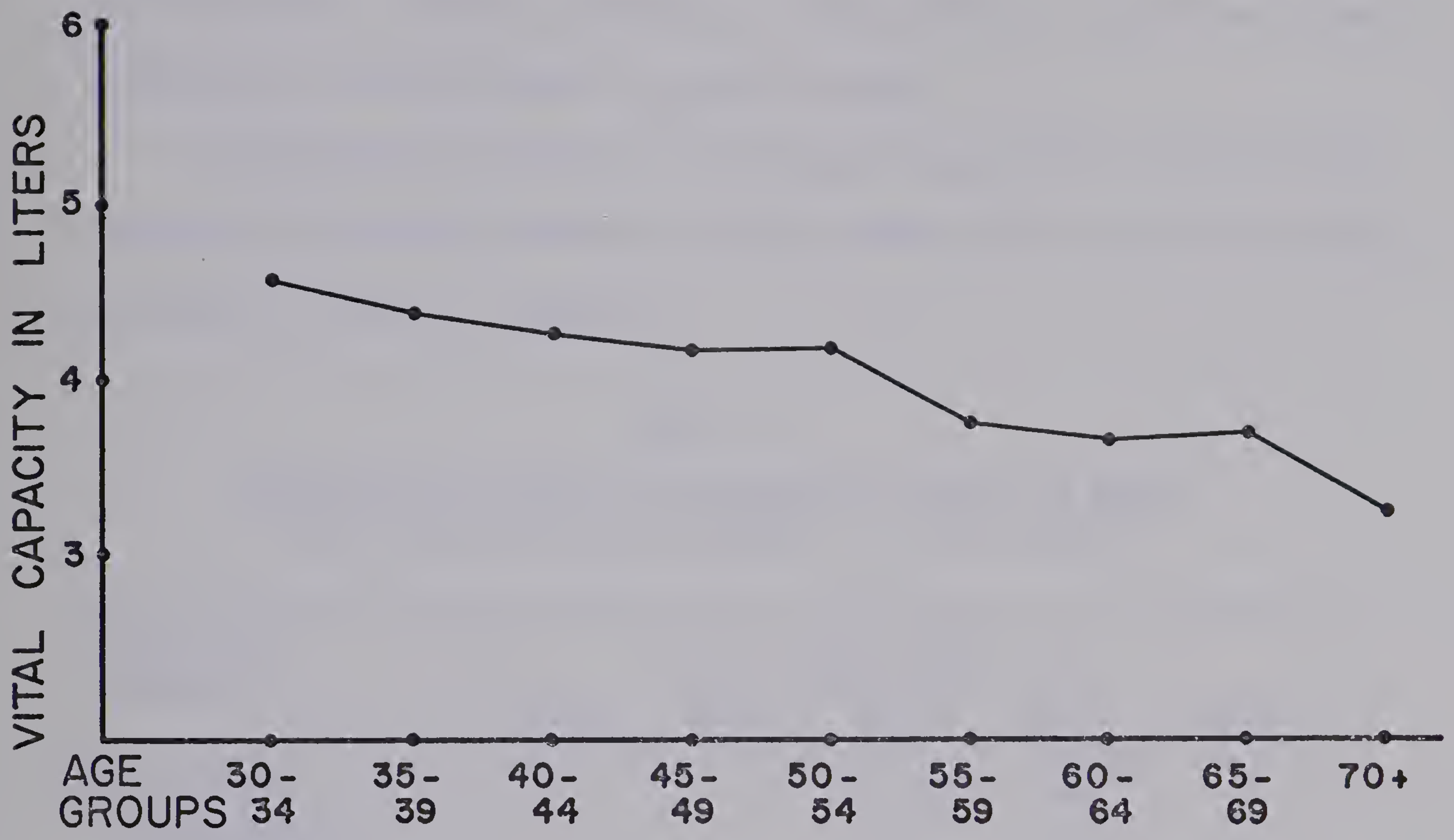

Fig. II VITAL CAPACITY BY AGE GROUPS

The results show the expected decrease with age. This decrease is slow and gradual from ages 30 - 54 (figure II) with a more pronounced drop at the 55 - 59 year age group, a slow decline to age 69 and a more rapid drop in the age group 70 years and over.

A comparison was made with similar age groups with data from the literature, including sedentary, active, ethnic and occupational groups. The data is listed in table IX.

TABLE IX

COMPARISON OF MEAN VITAL CAPACITIES FROM THIS STUDY WITH DATA FROM THE LITERATURE - BY AGE GROUPS

Author and Subjects	Age Range Vital Capacity in Liters				
	30-39	40-49	50-59	60-69	70-79
Astrand (8) Truck drivers Caucasians	-	-	(n=73) 4.66	(n=8) 4.17	-
Boren (25) Caucasians	(n=119) 4.91	(n=116) 4.60	(n=43) 4.31	(n=29) 4.32	-
Grimby (60) and Saltin (96) Active athletes	-	(n=14) 4.90	(n=15) 4.20	(n=4) 3.20	-
Former athletes	-	(n=10) 5.00	(n=14) 4.60	(n=5) 4.30	-
Robinson (90) Caucasians	(n=10) 4.76	(n=10) 4.28	(n=9) 4.16	(n=8) 4.05	(n=3) 3.20
Shephard (103) Caucasians	(n=17) 4.64	(n=8) 4.41	(n=22) 4.23	(n=3) 3.73	-
This Study Rural population Main Study	(n=69) 4.50	(n=93) 4.25	(n=101) 4.00	(n=38) 3.70	(n=11) 3.30

No appreciable differences are apparent between the samples

compared in any age category, whether the sample was active or sedentary, including the results from the present study.

Discussion

Vital capacity has been shown to correlate highly with MVO_2 (11) when both are expressed in liters, and the vital capacity has been used as a measure of physical fitness (18). However, estimating MVO_2 from vital capacity measurements has been shown to be quite unreliable (18: 203).

The decrease in vital capacity with age is associated with an increased residual volume and decreased distensibility of the lungs (18). It is not certain whether training will increase the vital capacity or whether it is greater in athletes compared to non-athletes. Some studies have shown that vital capacity is superior in athletes (98, 115) while other studies have shown no difference (60, 95). Cumming (43) found no correlation between vital capacity and endurance events in boys when body size was taken into consideration.

It appears that body size is the most significant factor in determining vital capacity in the healthy subject, but may be reduced somewhat by heavy smoking (63, 98). For a complete analysis on the effects of training, smoking, or inactivity on vital capacity, subjects would have to be matched for body size.

Vital capacity is not an important determinant of MVO_2 (43) but its inclusion in a test battery may yield valuable information concerning the distensibility of the respiratory system (5, 18).

Skinfold Thicknesses - Main Study

A one-way analysis of variance for each of the four skinfolds measured was computed between age groups, and the results appear in Appendix C, tables XVIII, XIX, XX and XXI. Where applicable, a Newman-Keuls comparison between ordered means is presented with the respective analysis of variance.

The means and standard deviations of each skinfold (triceps, biceps, subscapula and suprailiac) are listed in table X by five year age groups, with a graphic representation shown in figure III.

TABLE X

MEANS AND STANDARD DEVIATIONS OF SKINFOLD THICKNESSES BY AGE GROUPS

MAIN STUDY

Age Group	N	Tricep (mm.)	Bicep (mm.)	Subscapula (mm.)	Suprailiac (mm.)
30-34	25	9.5 (4.8)	5.1 (2.2)	14.4 (6.2)	14.3 (7.0)
35-39	44	11.4 (5.9)	5.8 (2.6)	16.2 (6.7)	16.4 (7.4)
40-44	50	10.6 (3.9)	5.5 (2.0)	15.2 (5.2)	15.9 (6.4)
45-49	43	11.0 (4.2)	5.7 (2.1)	15.7 (5.7)	14.9 (5.7)
50-54	58	9.3 (2.9)	4.9 (2.0)	14.9 (5.2)	12.2 (5.5)
55-59	43	9.7 (3.1)	4.9 (1.8)	15.0 (5.0)	13.2 (6.3)
60-64	19	10.2 (2.9)	5.6 (2.4)	14.5 (4.1)	13.4 (5.8)
65-69	19	10.0 (3.6)	5.3 (1.8)	14.9 (5.2)	13.1 (6.5)
70- +	11	8.9 (2.9)	3.9 (1.0)	11.9 (3.4)	10.1 (4.6)
Overall	312	10.2 (4.1)	5.3 (2.1)	15.1 (5.4)	14.1 (6.4)

From the results, it is apparent that there was little variation in skinfold thicknesses between age groups for all skinfolds except the suprailiac (see Appendix C).

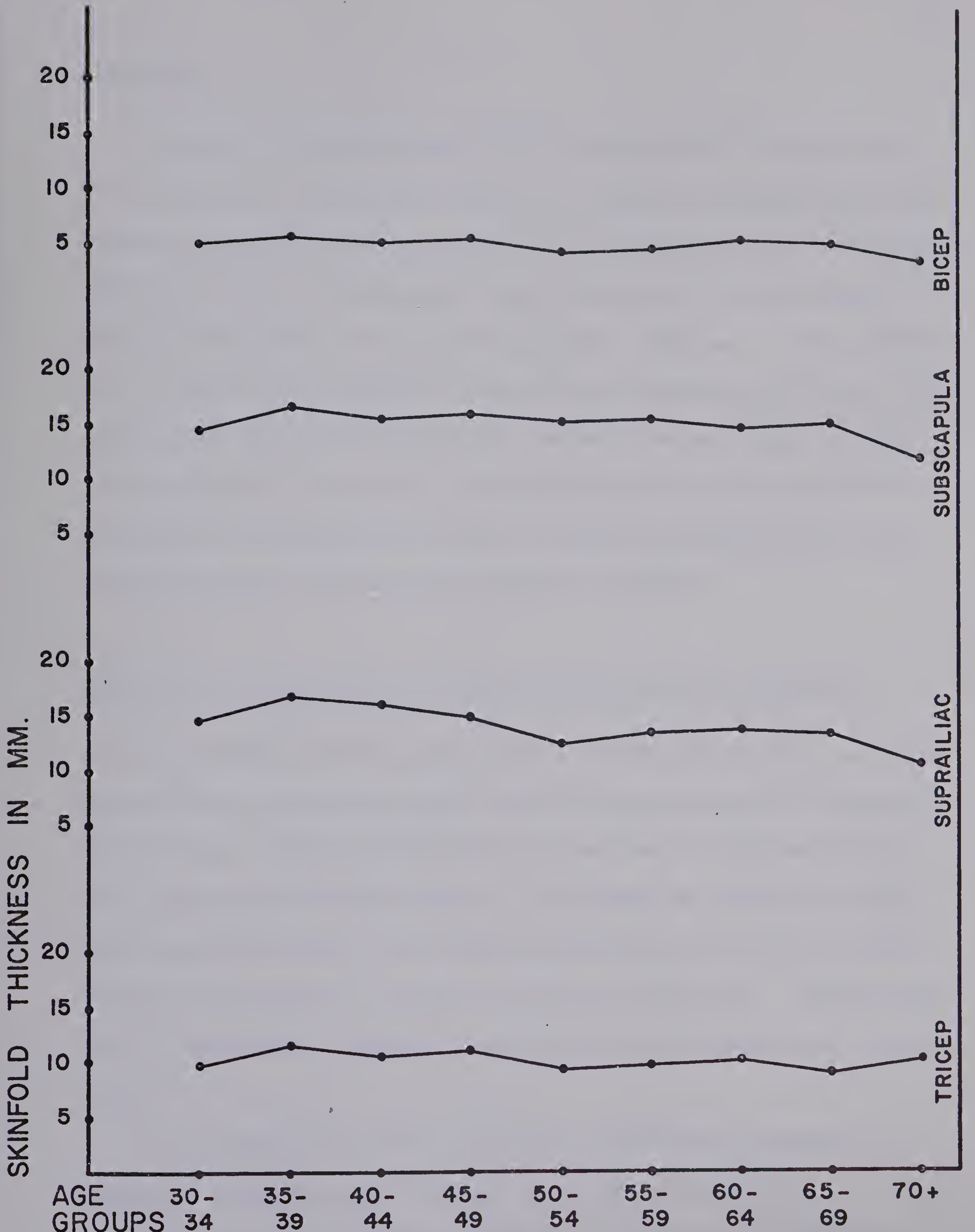

Fig. III SKINFOLD BY AGE GROUPS

Discussion

According to Keys and Brozek (70) and Brozek (29) the deposition of fat tends to increase with age and Siri (108) has commented that the increase continues up to the age of 55; the characteristics in senescence being less clear. In the present study, there was no trend toward increased fatness from the skinfolds measured. Since much of the skinfold data in recent years has been collected using standardized calipers, the stability of the skinfold thicknesses between the age groups is difficult to explain. It was only in the oldest age group that skinfold thicknesses varied (decreased) with the other age groups (figure III) and significantly only with the suprailiac skinfold.

Comparison of Skinfold Thicknesses with Data From the Literature

Many studies have been completed on skinfold thicknesses, and one common factor in the more recent studies has been the use of standardized calipers. However, the skinfold sites measured have varied, as well as age groups and age ranges. The triceps and subscapular skinfolds have been common sites in many studies and the results of these studies are presented in table XI by ten year age groups. Included are results from various sedentary, active, ethnic and occupational populations.

It is apparent that data on different populations arranged in decade age groupings (over wide age ranges) is not abundant.

From the results listed, the studies by Anderson (7), Brozek et al. (31) and Slome et al. (111) show an increase in skinfold thicknesses

TABLE XI

COMPARISON OF SKINFOLD THICKNESSES FROM THIS STUDY WITH DATA FROM THE LITERATURE - BY AGE GROUPS

Author	Age Range	N A*	N S**	Triceps A	Triceps S	Scapula A	Scapula S	Triceps & Scapula A	Triceps & Scapula S
		Mean Skinfolds in mm.'s and Activity Category							
Anderson (7)	30-39	-	58	-	12.6	-	18.8	-	31.4
Caucasians	40-49	-	34	-	16.4	-	20.4	-	36.8
Indians	50-59	-	30	-	18.8	-	22.6	-	41.4
Brozek (31)	40-49	524	350					33.9	36.1
Caucasians	50-59	311	508					36.0	38.
CAHPER (34) Canadian population	30-39	-	-	-	9.0	-	14.0	-	23.0
Elsner (53) Norwegian Lapps	30-39	27	-	7.0	-	9.0	-	16.0	-
Jansen (69) Papuans									
Biak and	30-39	16	-	4.7	-	6.8	-	11.5	-
Nubuai	40-49	6	-	4.0	-	6.9	-	10.9	-
Sorong	30-39	12	-	4.0	-	7.0	-	11.0	-
Mappia	30-39	11	-	2.9	-	6.0	-	8.9	-
Keys (70)									
U.S.A.	40-49	36	36	-	-	-	-	29.6	34.4
Sweden	40-49	21	21	-	-	-	-	19.9	21.5
Italy	40-49	33	33	-	-	-	-	17.4	22.2
Japan	40-49	45	45	-	-	-	-	17.0	25.5
Europeans	40-49	90	90	-	-	-	-	22.9	26.9
Total	40-49	135	135	-	-	-	-	20.9	26.5
Slome (111)									
Durban Zulus	30-39	-	32	-	8.3	-	-	-	-
	40-49	-	20	-	9.0	-	-	-	-
	50-59	-	21	-	11.6	-	-	-	-
African agricultural	30-39	-	-	4.7	-	-	-	-	-
workers	40-49	-	-	4.8	-	-	-	-	-
This Study	30-39	69	-	10.5	-	15.3	-	25.8	-
Rural population	40-49	93	-	10.9	-	15.5	-	26.4	-
Main Study	50-59	101	-	9.5	-	15.0	-	24.5	-
	60-69	38	-	10.1	-	14.8	-	24.9	-
	70-79	11	-	8.9	-	11.9	-	20.8	-

*A - active **S - sedentary

with age, contrary to the results from the present study and the results of other studies (87, 105). The trend between active and sedentary groups indicates less fatness in the active groups. Andersen and Hermansen (4) showed that the mean value of 10 skinfold sites measured on a sample of skiers was only 8.1 mm. compared to 12.6 and 12.5 mm. for industrial and office workers respectively. Each group was in the same age range. Similarly, Grimby and Saltin (60) found that the mean subscapular skinfold was 9.8 mm. for a sample of active old athletes 42 - 68 years of age, compared to a mean of 12.7 mm. for a sample of old former athletes (96).

The ethnic groups, other than the Canadian Indian, had mean skinfold values much smaller than the other groups.

The triceps and subscapular measurements were less in the present study, compared to the results from a sample of switchmen and clerks studied by Brozek et al. (31) for the age groups 40 - 49 and 50 - 59, and compared to a sample of active and inactive men from the U.S.A. reported by Keys (71). The European groups from the same study had smaller skinfold thicknesses in both activity categories, in relation to the results from the present study (40 - 49 year age group).

Discussion

Activity tends to reduce the amount of subcutaneous fat present at various sites in the body. North Americans tend to have more fat than Europeans (71), possibly because of more over-nutrition or less physical activity. The athletic groups appear to have less subcutaneous fat which may be attributed to regular physical exertion.

The ethnic groups (other than the Canadian Indians) have much less fat, possibly due to genetic constitution, or in the case of the groups studied by Jansen (69), to under-nutrition.

The results from the present study show less fatness in farmers compared to other North American occupational groups, possibly because of greater physical activity due to the various farming operations.

Brozek (29) discussed the importance of selecting skinfold sites in field surveys in terms of accessibility and validity, gauged from correlations with body density measurements. Shephard et al. (105) has shown that the suprailiac and subscapular skinfolds tend to be the best indicators of relative adiposity, and recommended that the triceps skinfold should not be used in adults, since this measurement fails to incraase with age. The goal is to select a minimum number of sites which are suitable for skinfold measurements and provide, in proper combination, the optimal measure of relative adiposity (29).

Percent Body Fat - Main Study

A one-way analysis of variance (Appendix C, table XXII) was carried out to determine the differences between age groups on percent body fat.

The means and standard deviations for percent body fat are presented in table XII by five year age groups, with a graphic representation shown in figure IV.

The analysis of variance showed no significant differences between age groups for percent body fat. The percentage remained relatively constant from age 30 - 49, decreased slightly in the 50 - 54 year age

TABLE XII

MEANS AND STANDARD DEVIATIONS OF PERCENT FAT BY AGE GROUP

MAIN STUDY

Age Group	N	Percent Fat	Standard Deviation
30-34	25	17.1	4.9
35-39	44	18.2	5.7
40-44	50	18.6	3.9
45-49	43	18.4	4.4
50-54	58	16.9	4.2
55-59	43	17.3	4.1
60-64	19	17.8	3.0
65-69	19	17.4	4.2
70- +	11	15.0	3.0
Overall	312	17.7	4.4

group, remained constant to the age of 69 and decreased slightly for the age group 70 years and over (figure IV).

Comparison of Percent Body Fat With Data From the Literature

Table XIII contains data on various sedentary, active, ethnic and occupational groups arranged in ten year ranges.

Discussion

There are many different methods for estimating percent body fat from regression equations developed in relation to body density (determined from underwater weighing). The estimations of percent body fat are determined with the greatest accuracy on the particular population used to develop the regression equations, and generally the particular procedure does not apply as favourably to other populations. Therefore,

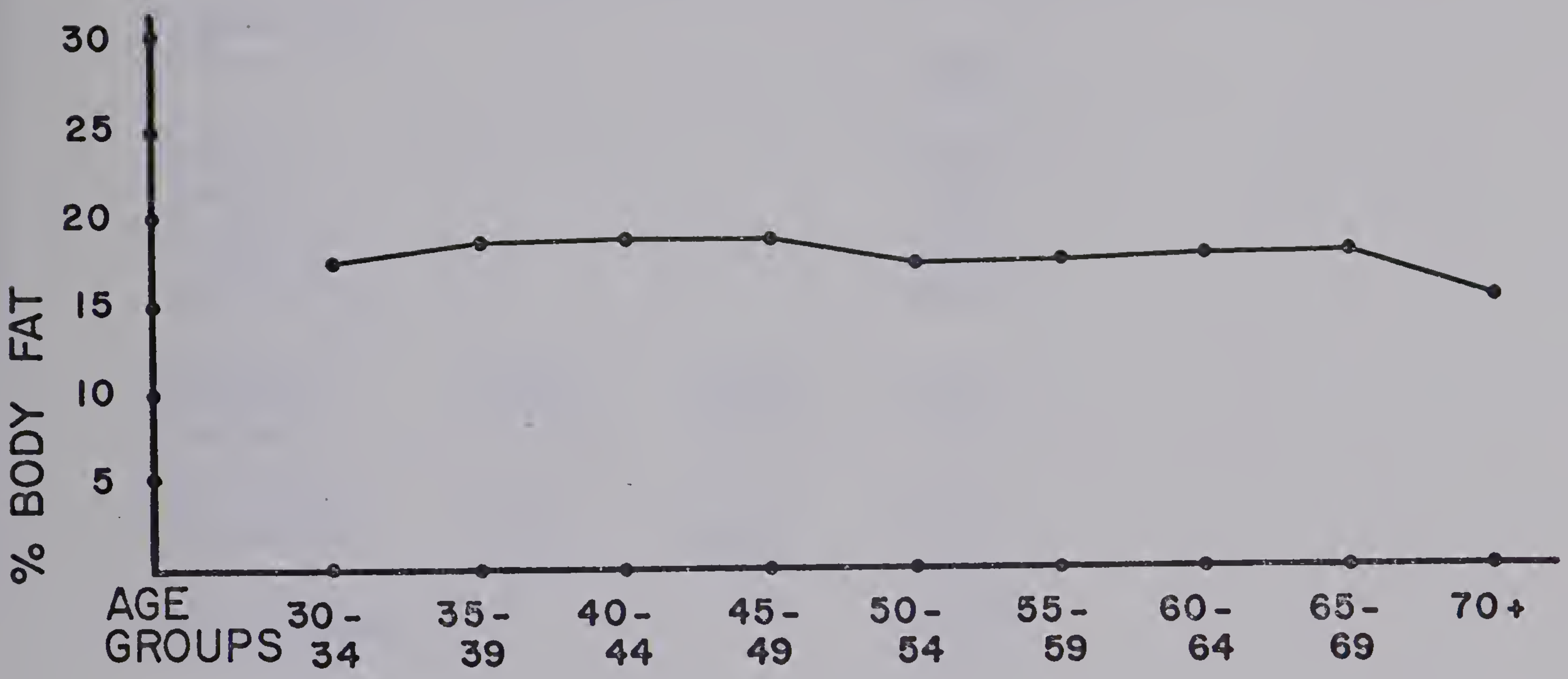

Fig. IV PERCENT BODY FAT BY AGE GROUPS

TABLE XIII

COMPARISONS OF MEAN PERCENT FAT FROM THIS STUDY WITH DATA FROM THE LITERATURE - BY AGE GROUPS

Author and Subjects	Age Range Percent Fat 30-39	40-49	50-59	60-69	70-79
Andersen (4)					
Skiers			(n=63) 16.0		
Office workers			(n=17) 19.0		
Industrial workers			(n=21) 23.0		
Anderson (7) Canadian Indians	(n=58) 12.5	(n=34) 17.3	(n=3) 20.4		
Brozek (28) Caucasians	(n=?) 17.4	(n=?) 21.6	(n=?) 24.5		
Active group			(n=29) 24.3		
Inactive group			(n=27) 27.3		
Crook (39) Caucasians	(n=72) 21.8				
Jansen (69) Papuans Biak and Nubuai	(n=16) 8.9	(n=6) 7.4			
Sorong	(n=12) 7.6				
Norris (84) Caucasians	(n=20) 27.9*	(n=34) 28.9	(n=30) 30.2	(n=25) 31.1	(n=21) 29.8
Orpin (85) Caucasians	(n=20) 14.0				
This Study Rural population	(n=69) 17.7	(n=93) 18.5	(n=101) 17.1	(n=38) 17.6	(n=11) 15.0

* Keys and Brozek 1953 formula (70).

comparisons of percent body fat by different methods must be made with these considerations in mind. Probably the most important characteristics to note are age trends, and the effects of activity levels within a particular population, as measured by one method.

The studies by Anderson (7) and Brozek and Keys (28) showed an increase in percent body fat with age, while the study conducted by Norris et al. (84) showed no appreciable change with age. Similarly, the results from the present study showed no increase in percent body fat with age. The reason may be due to the particular method employed (49) since the oldest subjects used in the cited study were only 34 years of age. If fat deposition increased with age, this may not have been accounted for by the formulae developed by the investigators. Nevertheless, the skinfolds measured in the present study, did not change appreciably with age.

Physical activity tends to decrease percent body fat as shown by Andersen and Hermansen (4) and Brozek and Keys (28) when comparing active and inactive groups. The percent body fat for each age group in the present study compared closely with the skiers studied by Andersen and Hermansen (4) in the age group 50 - 59. However, the methods of determining percent body fat in the two studies were different.

Hand Grip Strength - Main Study

A one-way analysis of variance was computed between age groups on hand grip strength, followed by a Newman-Keuls comparison between ordered means (Appendix C, table XXIII).

The means and standard deviations for hand grip strength are presented in table XIV and graphically in figure V by five year age groups.

TABLE XIV

MEANS AND STANDARD DEVIATIONS OF GRIP STRENGTH (DOMINANT HAND) BY AGE GROUPS

MAIN STUDY

Age Group	N	Grip Strength (Kg.'s)	Standard Deviation
30-34	25	57.9	7.7
35-39	44	55.2	8.0
40-44	50	53.7	7.8
45-49	43	52.4	11.7
50-54	58	50.8	6.9
55-59	43	48.5	7.1
60-64	19	46.6	8.5
65-69	19	40.8	7.8
70- +	11	39.7	6.9
Overall	312	51.1	9.3

Discussion

Hand grip strength declined as expected with increase in age. The mean grip strength for the age group 70+ was approximately 70% of the mean grip strength for the 30 - 34 year age group. There was a gradual drop in grip strength to the age of 64, with a more sudden drop at the age group 65 - 69 and a smaller decrease for the age group 70+ (figure V).

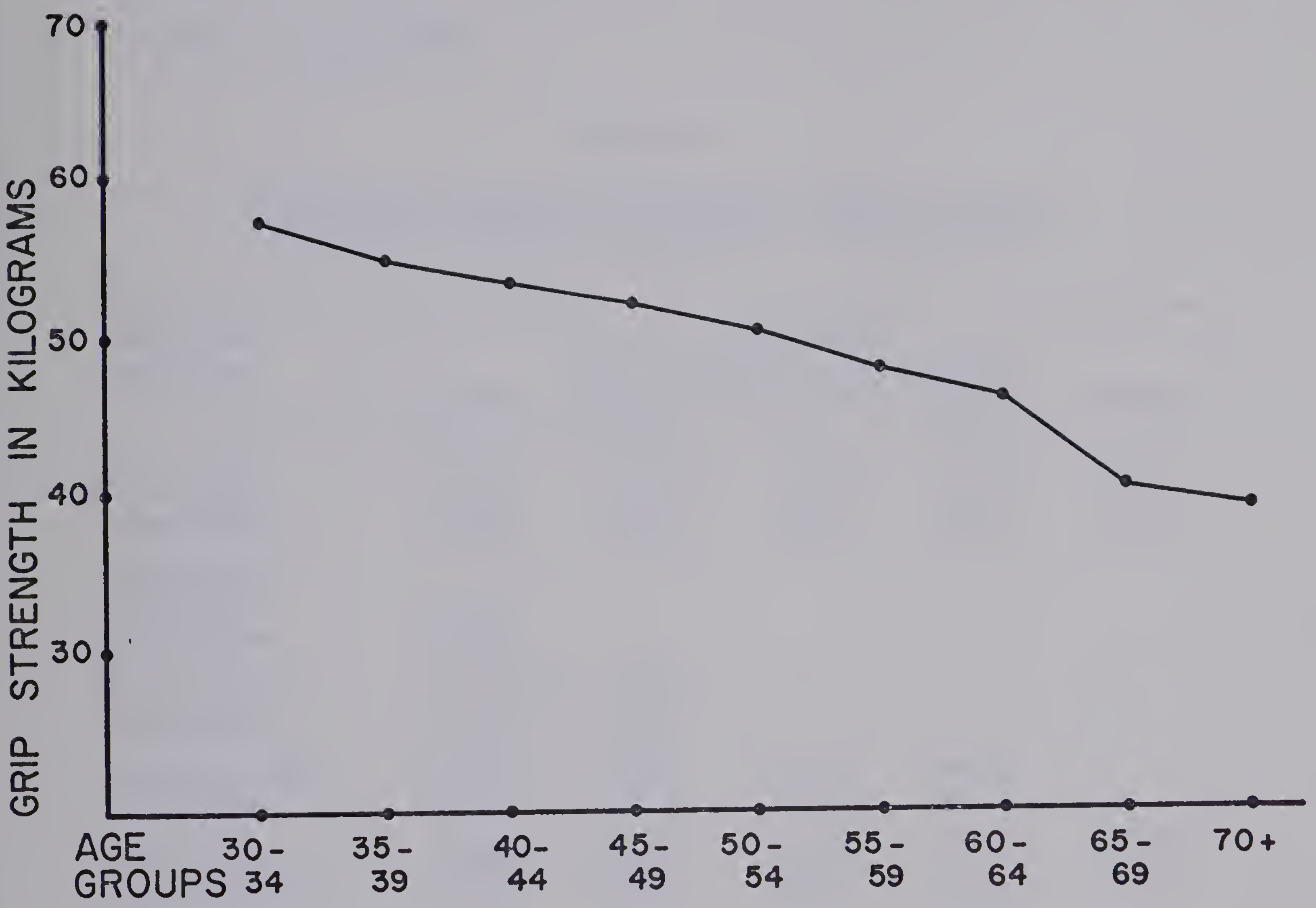

Fig. V GRIP STRENGTH BY AGE GROUPS

Comparison of Hand Grip Strength with Data From the Literature

A few studies on hand grip strength have been completed on various populations which include wide age ranges and are listed in table XV by ten year age groups.

TABLE XV

COMPARISON OF MEAN GRIP STRENGTHS FROM THIS STUDY WITH DATA FROM THE LITERATURE - BY AGE GROUPS

Author and Subjects	Age Range Grip Strength in Kilograms 30-39	40-49	50-59	60-69	70-79
Burke (32) Caucasians	(n=30) 50.7	(n=30) 49.1	(n=20) 45.9	(n=20) 44.3	(n=7) 32.7
CAHPER (34) Canadian population	(n=?) 53.0				
Fisher (55) Caucasians	(n=198) 52.9	(n=71) 49.9	-	-	-
Shephard (103) Caucasians	(n=17) 52.1	(n=8) 55.2	(n=22) 47.0	(n=3) 44.1	-
This Study Rural population Main Study	(n=69) 56.6	(n=93) 53.1	(n=101) 49.7	(n=38) 43.8	(n=11) 39.7

The results from the present study are generally higher for each age category compared to the other studies in table XV.

Discussion

Hand grip strength may be higher in farmers compared to more sedentary groups because of various jobs that may increase the strength of

the forearm muscles. However, Shephard et al. (103) found that the level of activity was not associated with hand grip strength. The results from the present study are only marginally superior to the results from the Canadian national adult survey, carried out under the auspices of CAHPER. However, only one age group could be compared (30 - 39 years).

Measurement of hand grip strength is relatively easy to standardize in field conditions, but its value as an indicator of all-round strength is questionable since Asmussen et al. and Lambert (18) have shown that correlations between different muscle groups in the body are quite low.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of the main study was to measure and compare (between five year age groups) the parameters of estimated MVO_2, vital capacity, skinfold thicknesses and percent body fat, and hand grip strength on a rural population of males 30 years of age and over.

The main study was accomplished by visiting a number of agricultural exhibitions and fair-days throughout rural Manitoba during the period June 11 to July 31, 1971. The testing center consisted of a house-trailer with the appropriate equipment installed for use inside the unit.

Subjects were selected on a volunteer basis. Each subject was asked to answer a questionnaire before testing began to determine smoking habits, health status (particularly relating to heart conditions), type of farm operation and recreational activities. A total of three hundred and twelve subjects participated in the main study.

The estimated MVO_2 was determined from one submaximal work load based on the nomogram of Astrand and Rhyming. The estimated MVO_2's were calculated using a computer program designed for the Olivetti Programma 101. A correction factor, based on age, was used to correct estimated MVO_2's for older subjects. MVO_2's were expressed in ml./kg./min.

Vital capacity, measured in liters, was measured utilizing a Collins-wet vitalometer. The larger value of two trials was used for statistical

treatment.

Skinfold measurements included the triceps, biceps, subscapula and suprailiac sites and were measured (in millimeters) by employing a Harpenden skinfold caliper. The sum of these four skinfold sites was used to estimate percent body fat.

Hand grip strength was determined by employing an adjustable Stoelting hand grip dynamometer. The dominant hand was used and the better of two trials was recorded for statistical treatment.

The major purpose of the secondary study was to measure the MVO_2 directly. This study was completed in the spring of 1969 on a group of male subjects 30 years of age and over from one rural municipality in Manitoba. All of the subjects were screened by a cardiologist before being allowed to participate in the maximal bicycle ergometer test. A total of forty-seven subjects participated in the secondary study.

Actual MVO_2's were determined by employing a Monark bicycle ergometer. The test was continuous, including two submaximal work loads of six minutes each and one maximal work load lasting three minutes. A 30 second sample of expired air was collected into each of two meteorological balloons and percent oxygen was analyzed using a Beckman E-2 analyzer, percent CO_2 using a Beckman LB-1 analyzer and expired air volume using an American Meter Company spirometer. Estimated MVO_2's from the secondary study were determined from the second submaximal work load by the same procedure in the main study.

Subsidiary purposes of the total study were to compare the estimated MVO_2's from the main and secondary studies with the observed MVO_2's from the secondary study. Further purposes were to compare the MVO_2 data from

both studies and the measures of vital capacity, skinfolds and percent body fat, and hand grip strength from the main study with pertinent data from the literature.

Statistical analyses included one-way analyses of variance and Newman-Keuls comparisons between ordered means on all parameters measured in the main study. A correlational analysis on all parameters (total group) measured in the main study was also carried out. These analyses were completed employing the IBM 360/67 computer facilities at the University of Alberta. A t-test programmed for the Olivetti Programma 101 was used to test the difference between the means of the observed and estimated MVO_2's, determined in the secondary study.

Results

Nutritional status of the subjects from both studies was assumed to be more than adequate. The majority of subjects had stopped smoking and the majority of those who did smoke, consumed not more than 10 - 15 cigarettes per day. The majority of the subjects in the main study and all of the subjects in the secondary study were actively engaged in farming. The major recreational activities were curling in winter and golf in the summer.

The estimated MVO_2's from the main and secondary studies and the observed MVO_2's from the secondary study showed the expected decline with increase in age. The mean observed MVO_2 for the complete sample from the secondary study was 16.5% greater than the overall mean estimated MVO_2 from the secondary study, and 24.4% greater than the overall mean

estimated MVO_2 from the main study. The overall mean estimated MVO_2 from the secondary study was 9.4% greater than the corresponding mean from the main study. The difference between the overall mean estimated MVO_2 and mean observed MVO_2 from the secondary study was significance at the 0.01 level. When the mean maximal heart rate for each age group was used as the correction factor for estimating MVO_2 in the secondary study, the underestimation in relation to the observed MVO_2 was reduced to 10.9%. If the estimated MVO_2's from the secondary study were increased 8%, the difference between the observed and estimated values would be slight.

The estimated MVO_2's from the main and secondary studies in most cases did not compare favourably with data from the literature on sedentary, ethnic and occupational groups and especially athletic and active groups. The mean observed MVO_2's by ten year age groups were generally higher than the respective means for sedentary populations, generally the same compared to other occupational groups but less compared to active and athletic groups.

The vital capacity results from the main study showed the expected decline with age. The mean vital capacities for each ten year age group were generally the same, compared with data from the literature.

The triceps, biceps, subscapular and suprailiac skinfolds measured in the main study showed little change with age, as did percent body fat estimated from these skinfolds, contrary to data from the literature. The triceps and subscapular skinfolds expressed as means for each age group, were less compared to sedentary populations and more compared to some active populations. Similarly, percent body fat was less compared

to more sedentary groups.

Hand grip strength measured in the main study showed the expected decline with age. In most cases the mean hand grip strength by ten year age groups, was higher compared to data selected from the literature.

Conclusions

From the results of the main and secondary studies, the following conclusions are warranted:

1. The majority of subjects in both studies were in good health at the time of testing.

2. It appears that farmers are more physically fit (in terms of aerobic power) than sedentary populations, when the observed MVO_2's from the secondary study were used for comparison.

3. The Astrand-Rhyming nomogram seriously underestimated MVO_2 (main and secondary studies) using age category for correction factors. There was considerable improvement when mean maximal heart rate for each age category was used for correction factors for estimating MVO_2 (secondary study).

4. If the procedure for estimating MVO_2 is well standardized and mean maximal heart rates for each age group are used to correct for age, estimated MVO_2's may be determined to within 8 - 10% of observed values.

5. The average values for vital capacity from the main study compared favourably with data from the literature.

6. Skinfold thicknesses and percent body fat measured in the main study did not change with age, contrary to data from the literature, and

this is possibly due to regular physical exertion necessary to carry out various farming activities.

7. Hand grip strength appears to be greater in farmers compared to other populations, possibly because of various jobs that develop the muscles of the forearm.

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APPENDIX A

THE CHILDREN'S HOSPITAL
OF WINNIPEG

Tel. – Area Code 204 – 775-8311 – 685 Bannatyne Ave., Winnipeg 3, Manitoba

May 14, 1971

Dear Sir:

I am writing to ask for permission to have a small fitness testing station at your forthcoming Fair. This would involve moving a small trailer, up to 16 feet in length, onto the Fair Grounds for the purpose of obtaining some heart and lung fitness tests in a rural population. We would hope a location would be available to attract sufficient volunteers for the test. We would require 110 volt power - low voltage (about 750).

We have done a study of a similar type in other rural populations as well as in a large city population, but are interested in collecting more subjects. We are chiefly interested in men 40 years of age and over. The testing is quite short, takes 10-15 minutes, involves no needles, only moderate exercise on a test bicycle for 5 minutes.

I think this may add to the interest in your Fair, each volunteer will be given a brief explanation of the test and the values he obtained, and so may be of some use to the individual, and, as well, will provide information for our current research conducted through the auspices of the University of Manitoba, the Children's Hospital of Winnipeg, and the Department of National Health and Welfare.

Your early reply as to the feasibility of carrying out this test at your Fair would be appreciated. If permission is granted, we would like to place a small note in the local newspaper advising of the study.

Yours truly,

GRC/meh

Gordon R. Cumming, M.D.
Cardiologist

Letter to Local Newspapers, Television and Radio

FITNESS TESTING AT FAIR

There will be a trailer at the fair grounds equipped for testing physical fitness. Measurements are to be made of strength, lung volume, and electrocardiographic response to six minutes of moderate bicycle exercise. Previous studies suggest that heart problems are less prevalent in rural populations, and there are less changes in the electrocardiogram in response to exercise in rural compared to city dwellers. The object of the testing at the fair grounds is to obtain a larger study of rural men, aged 40 to 65, and their electrocardiographic response to exercise. The testing will be carried out by two graduate physical educators with special training in fitness testing. The testing requires 10 to 12 minutes per person, and is of submaximal intensity and will not be tiring. The test this year is directed at men aged 40 to 65 years, and, if the response to this pilot program is satisfactory, future projects are likely aimed at studies of other age groups and women. The tests are financed through a research grant from the Federal Department of National Health and Welfare.

Questionnaire

COUNTRY FAIR STUDY

NAME ______ 7 ______ 18 FAMILY DOCTOR ______

ADDRESS ______

AGE - years	20	EKG - REST	90
HEIGHT - cm	23	- EXERCISE	91
WEIGHT - kg	27	- RECOVERY	92
BICEPS	30	ANY HEART PROBLEM	93
TRICEPS	33	ANY CHEST PAIN	94
ILIAC	36	WHERE	95
SCAPULA	39	WHAT BRINGS IT ON	96
TOTAL	43	ANY OTHER HEALTH PROBLEM	97
STRENGTH	45	RECREATIONAL ACTIVITIES	98
VITAL CAPACITY	47	FARMER	99
CIGARETTES/day	49	TYPE OF FARM	100
WORK LOAD	53	NO. OF CULTIVATED ACRES	101
B.P. REST - SYSTOLE	56	NO. OF LIVESTOCK	102
- DIASTOLE	59	WHEN DID YOU LAST EAT	103
B.P. EXERCISE - SYSTOLE	62	DRINKING SHORTLY BEFORE	104
- DIASTOLE	65	% FAT	107
H.R. - REST	68		
2'	71		
4'	74		
5.5'	77		
IMMED. RECOVERY	80		
2' RECOVERY	83		
PREDICTED $\dot{V}O_2$ L/min	86		
$\dot{V}O_2$ - ml/kg/min	89		

CONSENT TO PARTICIPATE IN EXERCISE TEST ______

Individual Fitness Test Report

BRIEF FITNESS TEST REPORT

		Average	Yours
HAND STRENGTH - kilograms		40	______
LUNG VOLUME - liters		3.7-5.0	______
ENDURANCE FITNESS	Age 20-30	45	______
Maximum Oxygen Uptake	Age 30-40	35	______
ml/kg/min.	Age 40-50	30	______
	Age 50-60	28	______
	Age 60-80	23	______

APPENDIX B

DETERMINATION OF ESTIMATED MVO_2

EMPLOYING THE OLIVETTI PROGRAMMA 101

The format employed to convert submaximal work load and submaximal heart rate into maximal oxygen uptake was based on data used to develop the Astrand-Rhyming nomogram (12). The premises are that oxygen consumption varies with submaximal work load; the oxygen consumption is then expressed as a percentage of maximal oxygen consumption depending on submaximal heart rate (based on a maximal heart rate of 195 beats per minute). Therefore, oxygen consumption at a heart rate of 128 = 50% of maximal oxygen consumption and a heart rate of 154 = 70% of maximal oxygen consumption (12).

A regression equation was formulated to convert submaximal work load into oxygen consumption (constant efficiency was assumed at each work load), employing each work load and corresponding oxygen consumption from the Astrand-Rhyming nomogram. The equation derived was:

$$\hat{Y} = .00229\ X + .071 \qquad \text{where,}$$

$\hat{Y}$ = the predicted submaximal oxygen consumption, and

X = the submaximal work load.

It was then necessary to express the oxygen consumption determined in equation 1 as a percentage of maximal oxygen consumption based on the determined submaximal heart rate from the work load performed (based on a maximal heart rate of 195 beats per minute).

The regression equation was derived from:

$$\text{slope} = \frac{y^2 - y^1}{x^2 - x^1} \qquad \text{where,}$$

y^2 and y^1 = %'s of MVO_2 and

x^2 and x^1 = submaximal heart rates, therefore

$$\text{slope} = \frac{70 - 50}{154 - 128}$$

The resulting equation was:

$$Y = .769\,X - 48.46 \qquad \text{where,}$$

Y = predicted percentage of maximal oxygen uptake, and

X = submaximal heart rate.

Maximal oxygen consumption was determined by:

$$MVO_2 = \frac{VO_2 \text{ submax}}{\%\text{ of max}} \text{ in liters per minute.}$$

Relative maximal oxygen uptake was determined by dividing body weight in kilograms into maximal oxygen uptake in liters per minute, and expressing as milliliters per kilogram per minute.

Because of the decline in maximal heart rate with age, a correction factor (10) was used (based on age group) (18:620) to correct the absolute value for maximal oxygen uptake, with subsequent division by body weight. If the mean maximal heart rate for a particular sample or population is known, the correction factors calculated by Astrand (10) may be used instead of the factors based on age (18:620).

The sequence of equations described above were programmed into a magnetic tape designed for the Olivetti Programma 101. All predicted maximal oxygen uptakes were calculated using this program which were

subsequently checked for errors in input. The program was tested against data in Astrand and Rodahl's book, Textbook of Work Physiology (18).

APPENDIX C

The following one-way analyses of variance and Newman-Keuls comparisons between ordered means on the major parameters from the main study were completed employing the IBM 360/67 computer apparatus at the University of Alberta. The correlation matrix on all age groups was also determined by use of this installation. Source programs were obtained from the University of Alberta Division of Educational Research Services publication entitled Program Documentation - 1968.

TABLE XVI

ONE-WAY ANALYSIS OF VARIANCE - ESTIMATED MVO_2 ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	4,450.813	556.35	8	14.48	0.000001
Error	11,639.500	38.41	303		

NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS OF ESTIMATED MVO_2's ON AGE GROUPS - MAIN STUDY

Order	1	2	3*	4**	5	6*	8	7**	9
Age Group	30-34	35-39	40-44	45-49	50-54	55-59	65-69	60-64	70-+

*,** significant at the 0.05 level; remaining differences at the 0.01 level of significance.

TABLE XVII

ONE-WAY ANALYSIS OF VARIANCE - VITAL CAPACITY ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	29.961	3.75	8	6.86	0.000002
Error	165.500	0.55	303		

NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS OF VITAL CAPACITY ON AGE GROUPS - MAIN STUDY

Order	1	*2	3**	4	5	$*6*^{0}$	$7*^{0}$	8**	$9*^{0}$
Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-+

$*, *^{0}, **$ significant at the 0.05 level; remaining differences significant at the 0.01 level of significance.

TABLE XVIII

ONE-WAY ANALYSIS OF VARIANCE - TRICEPS SKINFOLD ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	184.152	23.02	8	1.40	0.198
Error	4,998.762	16.50	303		

TABLE XIX

ONE-WAY ANALYSIS OF VARIANCE - BICEPS SKINFOLD ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	56.973	7.12	8	1.62	0.118
Error	1,330.648	4.39	303		

TABLE XX

ONE-WAY ANALYSIS OF VARIANCE - SUBSCAPULA SKINFOLD ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	202.875	25.36	8	0.85	0.558
Error	9,024.563	29.78	303		

TABLE XXI

ONE-WAY ANALYSIS OF VARIANCE - SUPRAILIAC SKINFOLD
ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	868.133	108.52	8	2.78	0.006
Error	11,842.398	39.08	303		

NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
OF SUPRAILIAC SKINFOLDS ON AGE GROUPS - MAIN STUDY

Order	2	3*	4	1	7	6	8	5	9*
Age Group	35-39	40-44	45-49	30-34	60-64	55-59	65-69	50-54	70-+

*significant at the 0.05 level; remaining difference at the 0.01 level of significance.

TABLE XXII

ONE-WAY ANALYSIS OF VARIANCE - PERCENT FAT
ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	209.750	26.22	8	1.36	0.212
Error	5,825.125	19.22	303		

TABLE XXIII

ONE-WAY ANALYSIS OF VARIANCE - GRIP STRENGTH ON AGE GROUPS - MAIN STUDY

	Sum of Squares	Mean Square	Degrees of Freedom	F Ratio	P
Groups	6,390.375	798.80	8	11.69	0.000003
Error	20,700.375	68.32	303		

NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS OF GRIP STRENGTH ON AGE GROUPS - MAIN STUDY

Order	1*	2**	*3	4	5*	6**	*7*^{0}	8*^{0}	9
Age Group	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-+

,^{0},^{00} significant at the 0.05 level, remaining differences at the 0.01 level of significance.

TABLE XXIV

CORRELATION MATRIX ON MAJOR PARAMETERS - ALL AGE GROUPS - MAIN STUDY

Parameters	1 Age	2 Weight	3 Tricep	4 Bicep	5 Scapula	6 Iliac	7 % Fat	8 Work Heart Rate	9 Work Load	10 Estimated MVO_2	11 Grip Strength	12 Vital Capacity
1	--											
2	-.21*	--										
3	-.08	.59*	--									
4	-.09	.60*	.72*	--								
5	-.07	.55*	.59*	.63*	--							
6	-.19*	.62*	.59*	.65*	.64*	--						
7	-.09	.61*	.63*	.71*	.76*	.85*	--					
8	-.59*	-.00	-.04	.02	-.08	.08	.03	--				
9	-.69*	.25*	.00	-.02	-.08	.11**	.00	.63*	--			
10	-.49*	-.25*	-.26*	-.34*	-.29*	-.24*	-.36*	.01	.58*	--		
11	-.49*	.41*	.10	.13**	.19*	.24*	.23*	.31*	.41*	.11	--	
12	-.39*	.18*	-.03	-.05	-.06	-.00	.00	.26*	.42*	.24*	.42*	--

*significant at the 0.01 level of confidence

**significant at the 0.05 level of confidence

APPENDIX D

TABLE XXV

RAW DATA FROM THE MAIN STUDY

PARAMETERS*

*1 Subject number
2 Age - years
3 Height - centimeters
4 Weight - kilograms
5 Triceps - millimeters
6 Biceps - millimeters
7 Subscapula - millimeters
8 Supra-iliac - millimeters
9 Percent fat
10 Resting heart rate - beats/min.
11 Submaximal work heart rate - beats/min.
12 Submaximal work load - kpm/min.
13 Recovery heart rate - beats/min.
14 Predicted MVO_2 - ml./kg./min.
15 Grip strength - kilograms
16 Vital capacity - liters

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
30-34	001	33	180	82.3	11.0	7.1	13.2	18.5	20.9	62	159	993	97	33.5	64	4.7
	002	34	185	85.0	6.8	5.3	21.3	16.4	19.9	70	146	1023	121	38.6	66	4.7
	003	32	180	75.7	8.2	3.5	14.0	12.9	16.6	103	175	921	125	33.4	55	4.0
	004	31	172	71.0	6.8	3.7	9.7	11.6	14.2	64	167	975	108	40.5	46	3.7
	005	31	173	65.4	5.1	3.0	7.2	5.9	9.6	83	169	872	98	38.6	55	5.0
	006	33	188	84.5	8.0	2.8	9.2	8.6	12.9	78	163	1258	96	45.3	54	5.5
	007	34	187	72.3	3.4	2.9	8.0	9.6	10.9	91	153	954	110	44.9	66	4.2
	008	30	179	72.3	6.0	2.8	8.5	5.7	10.5	80	164	990	112	41.6	64	5.2
	009	30	181	101.0	12.2	6.4	20.2	23.6	21.8	83	175	1210	117	32.6	75	5.4
	010	34	172	96.4	26.1	8.8	28.0	26.6	26.4	82	141	798	92	32.7	46	4.8
	011	30	180	90.0	7.8	4.5	11.6	12.1	15.8	90	157	1148	106	41.4	46	5.4
	012	33	176	82.6	10.7	3.5	13.8	14.0	17.6	83	183	906	133	28.0	57	4.0
	013	34	175	71.0	9.2	4.4	13.4	9.8	16.0	86	159	936	114	42.2	55	4.1
	014	33	185	88.5	9.0	6.5	18.7	17.5	20.3	54	127	818	79	44.6	59	4.5
	015	31	174	76.0	11.6	5.8	28.9	18.2	22.9	92	156	981	106	42.6	60	4.6

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	016	34	192	90.7	9.8	7.1	17.2	16.9	20.2	117	173	874	123	27.0	45	4.5
	017	30	179	98.8	18.3	11.5	20.2	37.1	26.9	65	159	1014	90	32.7	63	4.8
	018	31	180	72.8	5.2	3.3	9.3	7.4	11.5	81	163	1103	123	46.2	65	4.5
	019	30	173	70.5	6.2	3.8	9.3	11.2	13.7	58	164	930	104	40.1	60	4.1
	020	33	183	81.5	8.1	4.8	17.2	14.2	18.3	80	153	800	106	33.7	52	4.9
	021	33	180	76.0	14.9	7.8	13.1	14.0	20.0	74	153	850	78	38.2	61	3.6
	022	30	170	77.7	10.6	6.1	20.3	17.2	21.0	78	163	900	118	35.6	55	4.2
	023	33	174	77.2	10.6	4.8	14.4	12.0	17.5	61	161	918	100	37.3	50	4.3
	024	31	183	69.5	5.5	3.2	7.3	8.0	11.3	83	170	978	119	40.2	63	4.5
	025	32	180	75.0	5.8	3.0	7.2	8.8	11.4	56	144	960	104	48.5	65	4.6
35-39	026	39	183	85.0	10.8	7.2	22.3	24.5	23.9	84	162	1059	114	33.4	54	5.6
	027	37	172	89.5	12.2	5.6	22.6	16.4	21.4	89	157	939	110	29.8	56	4.1
	028	36	173	69.5	8.3	4.2	12.6	10.2	15.6	83	151	808	110	35.4	56	5.1
	029	39	173	81.0	9.2	5.0	17.2	20.1	20.1	110	170	927	136	28.5	52	3.5
	030	36	173	93.5	10.4	10.3	32.1	25.3	25.6	85	150	780	117	25.7	57	3.7
	031	38	178	96.6	0	0	0	0	0	76	150	960	111	30.5	53	0
	032	38	180	106.0	7.7	6.2	22.8	20.3	21.4	92	150	999	117	28.8	71	5.4
	033	37	178	101.0	13.0	7.0	16.3	15.0	17.4	84	141	1017	109	34.4	69	5.0
	034	39	178	79.0	9.4	4.2	10.4	9.0	14.7	99	143	785	106	33.3	57	4.7
	035	35	175	59.6	7.0	3.6	11.4	7.7	13.4	102	136	695	94	43.2	37	4.0
	036	35	175	75.0	11.8	4.0	10.4	13.4	16.8	87	159	903	114	33.5	50	4.9
	037	35	186	133.0	18.8	9.4	14.5	35.0	25.4	91	159	1276	117	26.4	71	5.4
	038	39	185	89.0	16.4	8.0	13.3	14.5	20.4	80	142	1114	83	42.1	37	4.8
	039	38	183	112.0	17.2	12.8	12.0	28.2	24.0	66	144	859	100	25.4	52	3.7
	040	38	178	98.2	20.2	8.8	22.0	21.5	24.5	114	142	900	113	31.0	67	4.6
	041	39	176	69.5	4.3	3.1	10.5	10.5	12.9	76	170	1010	106	36.1	58	4.8
	042	38	183	79.6	6.0	3.0	8.0	8.4	11.6	65	143	1000	86	41.8	54	4.7
	043	38	178	85.0	11.7	5.4	11.7	20.3	19.7	77	156	927	109	31.3	60	4.6
	044	39	183	68.2	6.2	3.5	10.8	10.2	13.8	79	142	912	91	45.2	44	4.5
	045	39	170	103.7	37.2	12.2	36.4	15.6	-	82	114	813	78	41.2	44	3.7

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	046	36	173	71.8	10.2	4.3	15.0	14.4	18.2	72	149	950	77	41.0	60	4.8
	047	35	175	77.3	11.2	5.4	16.6	14.0	19.2	69	144	800	103	34.3	55	4.3
	048	38	185	92.5	16.5	7.4	24.0	18.1	23.2	85	142	700	107	25.8	63	3.7
	049	39	170	69.6	3.3	3.1	10.7	9.5	11.1	54	158	930	94	37.6	47	4.3
	050	37	186	81.0	12.4	4.2	12.0	18.6	19.2	55	142	1050	79	43.7	54	5.2
	051	36	173	82.6	14.8	7.2	15.6	15.8	20.7	112	169	900	119	27.4	57	4.7
	052	38	184	99.0	10.8	9.5	24.4	22.2	23.3	69	153	969	92	29.0	63	5.0
	053	35	169	71.0	4.4	3.7	8.7	8.4	11.6	98	152	750	106	31.9	43	4.2
	054	35	175	78.3	13.5	6.6	15.4	15.0	20.1	93	169	951	132	30.5	54	4.5
	055	36	168	83.6	14.3	8.2	23.6	12.1	21.6	84	123	480	96	26.3	48	3.5
	056	38	175	85.6	7.1	3.1	13.5	13.8	16.2	70	142	842	106	33.4	52	5.3
	057	35	180	75.5	8.0	4.4	13.8	12.6	16.6	100	170	850	125	28.2	50	4.5
	058	39	181	98.6	8.8	4.8	21.8	19.1	20.9	66	107	751	63	46.6	68	6.2
	059	37	165	70.5	11.0	5.6	18.1	36.6	24.2	77	142	691	104	33.5	51	2.9
	060	38	174	72.8	10.6	6.7	17.2	14.6	19.7	96	163	763	129	28.2	51	4.9
	061	35	168	76.4	7.0	3.6	13.3	15.8	16.9	72	140	900	90	40.9	57	3.7
	062	38	180	77.3	8.9	4.5	17.5	15.3	18.9	83	149	942	106	37.8	50	4.6
	063	35	177	93.0	13.8	6.4	20.4	12.2	20.5	70	163	1000	104	28.7	60	4.3
	064	35	175	70.0	5.2	3.6	8.5	10.5	12.6	80	156	788	101	32.5	60	5.1
	065	36	185	80.7	14.0	6.9	10.3	10.7	17.6	68	148	900	102	35.1	57	5.4
	066	39	177	80.5	10.2	5.8	17.2	13.2	18.9	62	153	1053	89	38.6	61	4.5
	067	39	180	95.5	13.5	5.1	22.1	33.0	24.7	101	169	1008	120	26.5	63	4.2
	068	39	174	86.4	10.9	5.4	12.8	16.2	18.6	65	139	936	86	38.0	45	4.5
	069	39	178	113.0	21.5	8.3	22.6	23.2	25.2	97	162	864	120	20.7	59	3.9
40-44	070	41	173	78.5	10.4	4.6	12.2	19.8	19.1	94	155	798	110	28.3	52	4.1
	071	44	175	73.6	9.2	5.3	12.4	14.5	17.4	85	173	1117	117	34.9	53	3.7
	072	43	188	83.2	9.2	4.6	9.7	8.3	14.2	104	147	763	119	28.0	52	4.5
	073	40	170	76.5	7.3	8.2	17.5	14.2	19.2	63	132	711	67	34.7	38	3.8
	074	43	184	86.0	6.8	4.8	13.6	10.8	15.8	100	168	891	133	25.1	69	4.5
	075	43	184	88.6	6.5	7.6	14.3	16.8	18.5	93	159	900	112	26.9	59	4.3

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	076	42	168	77.4	7.2	3.6	21.0	16.6	19.5	79	145	900	87	36.2	49	3.3
	077	40	178	75.0	16.5	6.2	20.0	20.1	22.6	83	176	845	95	25.4	51	4.5
	078	42	170	75.5	6.2	5.6	14.9	16.7	18.1	75	169	960	125	30.5	45	4.6
	079	43	169	61.8	4.4	3.2	8.7	9.3	11.7	67	132	770	80	46.3	44	3.6
	080	43	180	75.0	5.8	3.4	8.7	10.4	12.8	74	169	912	118	29.2	43	4.4
	081	40	178	75.9	10.2	4.2	12.6	7.2	15.2	65	149	918	110	35.8	52	5.0
	082	42	171	79.5	14.1	6.2	21.0	19.7	22.2	94	156	760	103	26.4	58	4.0
	083	42	178	83.5	10.2	6.2	11.0	13.8	17.4	98	155	790	114	26.3	52	4.4
	084	40	179	77.6	7.8	3.7	9.6	6.4	12.5	59	156	930	93	32.8	52	4.1
	085	43	174	73.7	6.0	3.8	9.4	11.4	13.7	94	138	800	93	37.1	62	4.6
	086	40	180	99.3	15.9	7.1	25.0	29.0	25.4	65	165	975	120	24.4	66	4.0
	087	41	180	88.0	8.4	3.3	12.1	17.8	17.5	86	147	942	106	32.4	68	5.4
	088	44	170	93.3	13.0	7.3	25.6	25.2	24.2	68	135	624	77	24.0	57	3.9
	089	42	183	100.0	20.5	7.3	22.5	20.5	24.0	95	159	1072	115	28.3	55	4.0
	090	42	189	92.6	8.3	5.0	12.6	17.3	17.9	68	165	1008	103	27.1	54	5.0
	091	41	176	82.6	13.8	4.8	14.2	13.2	18.8	85	132	912	98	40.8	58	4.1
	092	40	170	84.1	14.0	13.4	12.4	36.2	25.2	94	153	785	119	26.6	49	3.8
	093	43	180	83.2	8.8	5.0	14.5	10.4	16.6	93	166	1030	121	30.5	55	4.6
	094	43	170	74.0	13.8	6.1	22.1	21.2	22.6	78	157	773	128	28.4	47	4.2
	095	40	169	65.0	5.0	3.8	7.4	7.1	10.7	76	148	773	90	35.8	38	4.2
	096	43	180	100.0	10.7	7.0	28.0	22.3	23.6	56	151	978	100	28.3	58	5.8
	097	41	175	81.0	8.0	4.8	10.6	11.6	15.6	50	131	1100	50	50.7	53	4.5
	098	40	177	87.7	19.6	5.0	17.0	28.8	24.1	83	157	824	100	25.5	56	4.1
	099	42	178	74.7	12.4	4.4	11.4	12.6	17.2	47	155	930	77	34.5	46	3.5
	100	41	178	84.5	11.4	4.9	14.2	13.6	18.2	104	150	921	114	31.9	49	5.5
	101	43	170	86.4	13.5	8.5	19.8	24.0	23.2	84	161	939	121	28.2	60	4.9
	102	40	184	93.6	14.0	2.6	12.2	19.1	19.4	69	139	800	103	28.8	64	5.4
	103	43	170	80.4	12.8	4.6	27.6	13.0	21.6	75	153	878	107	30.9	45	3.8
	104	41	172	77.0	14.0	6.8	12.8	19.0	20.5	68	159	915	107	31.5	39	3.0
	105	43	170	81.5	13.1	8.6	18.6	27.6	23.6	76	165	810	110	24.9	50	3.4
	106	41	174	75.0	9.8	4.0	13.6	13.6	17.3	92	150	956	93	37.2	58	4.2
	107	41	169	75.0	5.0	4.2	13.3	10.3	14.6	77	163	924	96	31.4	52	3.8

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	108	41	167	76.0	13.5	7.7	18.6	17.8	21.5	64	134	915	96	43.2	45	3.8
	109	40	177	72.6	7.1	4.5	10.9	12.4	15.5	75	150	837	96	33.9	57	3.8
	110	41	174	88.5	10.7	5.2	18.1	21.5	21.1	100	159	924	116	27.7	56	3.2
	111	44	180	81.5	14.6	4.4	17.2	12.0	19.5	110	158	677	127	22.5	50	4.6
	112	42	171	74.6	11.2	5.2	13.4	11.4	17.4	82	161	921	119	32.1	59	4.5
	113	40	175	71.0	10.0	5.5	9.8	14.0	16.8	72	132	782	93	40.9	58	4.4
	114	43	177	91.0	20.4	11.2	18.5	15.0	22.8	110	156	644	132	19.7	66	4.3
	115	40	178	93.2	10.6	5.5	16.1	18.2	20.1	84	153	924	101	28.1	57	3.9
	116	40	183	87.5	11.0	5.6	16.0	16.8	19.8	112	156	664	117	21.0	66	5.0
	117	40	183	88.3	7.2	5.2	19.5	13.9	18.7	73	140	915	83	34.3	60	4.8
	118	40	178	76.4	5.3	3.7	8.6	6.2	10.9	70	154	903	109	33.1	64	4.8
	119	44	169	63.6	7.2	3.2	8.6	8.8	12.7	60	163	1004	108	40.1	40	4.7
45-49	120	45	180	80.0	7.3	3.1	10.2	11.3	14.3	83	132	909	92	39.4	51	4.1
	121	45	168	60.4	9.4	4.2	9.4	8.0	13.9	71	170	850	119	31.6	45	3.8
	122	45	180	74.5	8.1	3.4	9.2	9.6	13.6	77	135	864	110	38.7	64	4.1
	123	45	180	83.5	12.2	6.8	10.3	13.3	17.4	98	170	948	106	25.4	61	4.9
	124	45	141	65.0	9.8	5.8	14.5	9.1	16.5	96	152	656	119	27.4	43	2.9
	125	45	171	75.8	7.8	4.4	17.4	11.2	17.1	80	148	866	106	32.3	54	5.1
	126	45	172	76.8	8.0	4.2	18.2	15.0	18.6	94	144	770	107	29.8	56	4.0
	127	45	189	90.8	11.5	5.3	13.9	12.3	17.9	83	145	927	102	29.8	60	5.0
	128	45	168	64.6	11.0	5.2	13.4	12.8	17.7	86	146	763	92	34.2	47	3.3
	129	47	175	101.5	20.0	11.2	24.0	24.8	26.0	99	147	915	117	25.7	50	2.9
	130	48	175	89.0	9.6	6.7	28.8	24.3	23.9	83	140	602	99	21.3	56	3.8
	131	49	188	92.5	12.6	8.0	20.2	19.4	22.0	89	163	975	123	25.2	64	4.4
	132	48	174	77.2	7.4	5.8	16.4	9.3	16.7	70	141	918	105	36.5	55	3.7
	133	48	168	90.8	20.2	8.2	16.4	23.0	23.6	89	116	458	90	23.5	50	3.0
	134	46	178	81.7	16.6	7.0	20.6	23.2	23.5	92	140	936	101	35.7	71	4.1
	135	47	183	94.6	11.6	3.9	12.8	14.2	17.7	107	153	950	93	26.7	70	5.5
	136	48	178	97.6	11.1	5.9	22.0	20.0	21.8	83	133	765	92	27.0	51	3.3
	137	47	178	76.8	8.2	5.1	14.5	17.2	18.5	67	159	1020	103	33.1	54	5.0
	138	46	185	78.5	7.3	3.5	13.5	9.3	14.9	79	146	900	99	33.1	48	4.7

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	139	47	174	81.6	14.0	5.0	14.2	15.8	19.7	81	162	927	132	27.5	47	4.9
	140	49	175	72.3	9.6	3.8	13.0	12.0	16.5	69	150	837	94	32.0	57	5.0
	141	46	173	82.7	10.5	4.2	15.0	13.2	17.9	71	146	734	90	25.8	58	4.0
	142	48	178	100.0	16.0	7.2	21.5	22.4	23.4	64	153	900	93	24.0	56	3.9
	143	47	179	90.8	12.3	6.1	15.5	22.0	21.2	81	143	921	110	30.4	57	4.5
	144	47	169	70.0	9.8	6.0	20.5	18.0	20.9	81	132	798	101	39.7	41	3.0
	145	48	180	87.0	11.4	4.9	19.2	16.6	20.4	74	165	944	128	25.4	56	4.0
	146	48	165	67.3	10.2	6.6	15.6	14.4	18.9	75	173	844	123	27.3	50	3.5
	147	48	175	57.4	4.4	5.5	5.5	5.3	9.3	71	163	800	97	33.5	39	4.3
	148	46	164	50.0	5.1	2.6	6.4	4.2	7.8	82	153	722	109	38.8	39	3.5
	149	46	170	64.0	4.4	3.3	7.8	5.8	9.6	87	164	816	118	30.3	51	4.5
	150	46	170	73.0	6.4	4.6	14.1	13.4	16.6	83	142	622	98	26.2	44	4.5
	151	47	179	93.5	12.1	10.1	24.1	16.3	22.5	75	111	477	77	26.2	55	4.2
	152	46	180	76.5	13.4	4.6	11.6	11.4	17.3	122	163	634	123	20.1	61	5.0
	153	48	174	86.4	15.4	7.6	29.0	20.2	24.4	66	121	606	76	29.5	51	3.5
	154	47	179	99.0	13.4	6.7	15.2	16.6	20.4	83	142	927	108	28.4	68	4.2
	155	47	181	93.0	7.2	6.4	14.4	17.0	18.5	116	146	918	124	28.5	72	4.9
	156	46	180	87.5	10.0	5.0	15.0	12.2	17.6	73	139	1043	101	37.4	48	4.5
	157	48	175	74.1	6.8	3.0	9.9	8.4	12.8	67	138	893	93	38.5	53	4.0
	158	46	167	59.0	7.0	3.1	12.0	8.2	13.6	62	138	750	83	40.9	37	4.3
	159	49	180	94.0	19.2	9.6	23.0	25.4	25.4	74	123	410	93	18.0	49	4.4
	160	48	181	90.8	18.9	10.2	25.7	23.5	25.7	66	176	900	120	21.0	57	4.0
	161	49	175	80.0	8.4	2.9	11.0	12.2	15.3	66	131	900	81	39.6	56	5.0
	162	48	180	102.0	19.0	8.4	10.6	17.4	21.0	78	142	823	96	24.5	0	4.5
50-54	163	51	185	91.4	9.2	5.7	16.5	10.9	17.7	92	137	969	107	32.9	55	5.2
	164	51	175	97.7	12.6	6.7	27.1	21.5	23.6	107	166	638	128	14.8	62	3.6
	165	52	175	76.4	5.8	2.8	10.6	12.4	14.1	78	127	850	95	40.2	44	4.5
	166	54	173	78.6	9.6	4.8	17.7	12.6	18.4	69	141	906	99	34.0	50	3.7
	167	53	175	75.0	10.2	4.8	21.0	12.8	19.6	74	134	783	95	34.1	55	4.4
	168	53	178	97.0	15.3	6.6	25.0	22.5	23.9	87	119	626	89	26.9	55	3.6
	169	52	191	130.0	13.5	13.7	26.1	18.9	24.4	98	129	788	101	21.2	54	3.7

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	170	53	175	79.5	12.7	7.3	18.3	18.8	21.4	76	149	936	95	31.5	45	3.9
	171	50	162	70.0	7.4	5.0	15.2	8.4	15.8	78	143	630	98	26.3	44	3.3
	172	50	184	93.1	6.6	5.3	18.2	13.5	18.1	92	142	723	114	22.8	53	5.0
	173	50	180	87.3	11.0	6.0	20.8	20.2	21.6	76	128	614	89	25.3	62	3.0
	174	50	163	73.3	6.9	2.8	11.4	9.6	13.8	63	158	906	114	29.9	54	3.3
	175	50	180	78.5	6.3	3.8	12.3	20.6	17.9	85	135	800	95	32.7	54	4.4
	176	50	180	94.0	13.4	7.8	22.8	25.2	23.8	77	142	954	100	29.6	61	3.8
	177	50	173	63.5	11.2	4.2	10.8	8.2	15.3	74	150	704	82	29.6	39	4.0
	178	50	173	63.5	5.0	3.3	7.0	4.3	9.0	103	147	756	123	32.9	58	4.7
	179	53	168	86.9	13.2	8.4	20.0	14.2	21.2	83	128	600	95	24.9	49	2.9
	180	52	175	78.6	9.5	4.7	18.2	12.6	18.5	81	155	864	110	27.5	54	4.7
	181	51	171	64.6	5.4	3.7	12.2	8.9	13.6	76	150	856	101	35.1	54	4.9
	182	52	180	83.2	13.6	5.0	14.5	21.6	20.9	80	146	815	110	27.3	47	3.0
	183	53	183	80.0	6.8	3.0	7.4	8.0	11.6	103	155	850	117	26.7	70	5.8
	184	51	178	84.1	6.6	3.4	11.6	10.7	14.4	102	149	790	114	25.3	43	4.3
	185	51	174	77.7	8.2	4.5	12.1	11.3	15.8	84	138	663	101	26.5	52	3.7
	186	54	183	64.5	4.9	2.8	8.4	8.6	11.4	94	138	559	100	27.2	48	4.2
	187	53	184	72.3	7.0	3.2	8.1	4.5	10.4	69	136	904	68	39.5	44	5.0
	188	53	174	86.4	11.0	7.9	20.3	18.5	21.5	91	147	788	111	25.1	39	3.3
	189	54	173	69.0	12.0	3.4	15.0	7.2	16.3	63	122	515	65	29.8	48	4.0
	190	54	170	63.6	7.3	3.6	11.3	5.6	12.6	55	149	628	100	26.8	37	4.4
	191	53	188	79.5	9.0	3.8	11.0	5.6	13.3	97	143	825	115	30.0	49	4.7
	192	54	185	83.2	9.0	3.9	13.0	8.2	15.1	90	115	550	81	29.9	68	5.1
	193	52	188	89.0	9.4	5.8	16.5	10.6	17.7	96	150	900	119	26.7	61	5.0
	194	53	185	78.4	6.6	4.4	15.6	12.0	16.5	92	156	850	114	26.9	46	4.6
	195	53	169	76.4	10.2	6.6	22.2	12.1	20.3	79	162	750	123	22.9	50	3.3
	196	53	178	78.6	8.8	4.6	11.5	9.6	15.3	61	120	850	81	43.8	51	3.8
	197	53	181	77.3	14.4	6.8	13.3	19.0	20.9	77	149	677	103	23.7	51	3.1
	198	53	173	86.8	13.9	6.1	18.0	15.4	20.7	103	123	462	100	21.0	52	3.6
	199	52	183	86.7	10.8	2.8	12.8	9.0	15.6	105	143	751	104	25.1	51	5.7
	200	53	176	73.5	8.1	4.2	14.6	12.6	17.2	74	111	468	79	31.5	53	4.1
	201	53	179	80.5	11.8	7.8	16.0	13.4	19.7	73	138	788	94	30.2	44	3.6

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	202	51	174	84.0	10.4	5.6	20.6	22.0	21.7	74	127	763	92	32.9	54	3.9
	203	54	164	54.5	3.7	2.1	5.3	3.7	5.5	92	147	644	109	32.8	48	3.6
	204	52	177	70.0	7.9	3.4	12.6	11.3	15.6	88	144	760	97	31.0	52	3.9
	205	52	172	69.5	10.0	4.5	14.1	12.2	17.2	70	153	609	86	22.7	56	4.9
	206	53	172	81.7	11.5	5.3	17.6	10.5	18.5	101	149	600	125	20.0	48	3.9
	207	53	175	98.2	10.8	7.0	24.0	21.8	22.7	72	134	755	99	25.1	34	2.8
	208	51	175	66.0	3.8	2.5	6.6	4.2	7.0	85	134	750	98	37.1	42	4.3
	209	51	173	63.6	7.0	3.0	8.4	4.7	10.6	79	128	750	98	42.0	45	4.5
	210	51	178	83.5	7.3	4.0	13.5	22.7	19.3	67	137	816	76	30.5	50	3.6
	211	53	189	73.6	9.8	3.3	11.4	7.8	14.5	86	140	642	104	26.4	51	4.7
	212	53	177	89.0	12.0	5.4	17.2	10.8	18.6	77	136	945	91	33.5	50	4.5
	213	52	182	79.6	11.8	5.2	17.8	10.8	18.6	74	150	909	107	30.2	57	4.3
	214	53	175	86.0	5.5	5.3	19.8	10.4	17.3	107	136	459	115	17.3	59	4.6
	215	53	183	80.8	16.0	9.0	20.3	13.5	21.8	71	136	606	76	24.0	55	3.5
	216	54	173	74.5	8.4	3.2	11.0	6.3	13.0	69	134	889	84	38.7	47	4.1
	217	53	169	62.7	5.6	5.0	16.3	9.8	16.0	85	146	755	114	33.7	50	4.7
	218	54	176	71.7	8.5	3.8	9.9	7.1	13.2	72	147	850	92	32.6	43	4.4
	219	51	174	68.2	9.8	4.6	7.5	7.8	13.4	65	140	775	86	34.2	51	3.7
	220	54	195	91.0	7.8	3.6	9.3	12.4	14.7	84	142	881	89	28.2	51	6.0
55-59	221	55	176	91.0	13.7	6.1	9.5	11.3	17.2	80	117	684	89	30.7	58	3.5
	222	55	177	97.7	16.8	5.6	21.0	23.0	23.3	69	129	864	78	29.2	44	4.0
	223	55	174	83.2	11.3	5.0	15.5	21.5	20.6	69	121	745	85	33.9	47	4.1
	224	55	183	67.7	7.6	4.7	15.7	12.8	17.2	74	136	775	87	34.3	49	4.6
	225	55	179	74.5	5.4	3.0	7.2	4.2	9.0	94	124	462	100	22.8	44	3.8
	226	55	182	82.4	6.2	3.2	11.4	7.1	12.7	85	143	803	91	26.7	41	3.4
	227	55	177	84.5	8.7	3.9	21.5	15.8	19.9	84	135	667	100	24.1	66	3.7
	228	55	180	82.0	10.1	5.4	13.4	13.0	17.6	82	139	750	102	26.4	56	4.0
	229	55	166	75.0	11.8	4.5	16.5	11.5	18.3	83	134	608	93	25.3	42	3.5
	230	55	169	71.6	11.2	5.5	15.8	10.0	17.8	103	158	500	115	16.4	44	4.2
	231	55	177	80.4	10.4	6.0	20.0	14.0	20.1	91	135	802	99	30.3	50	4.7
	232	57	173	74.5	8.5	3.3	12.0	9.0	14.6	85	133	610	91	25.9	52	3.9

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	233	58	167	68.2	9.8	5.0	8.8	12.8	15.9	65	121	453	83	25.8	38	4.4
	234	59	168	66.5	9.2	3.9	13.2	9.4	15.7	69	139	608	111	26.6	40	3.3
	235	58	175	75.0	9.1	4.4	11.3	7.0	14.3	70	138	750	98	29.3	42	4.2
	236	57	173	70.5	9.0	5.6	17.5	18.0	20.0	73	150	711	106	25.5	35	4.0
	237	56	183	93.3	10.4	9.5	15.5	26.6	22.4	116	142	630	109	18.9	65	4.0
	238	56	180	76.2	7.2	4.6	14.2	8.0	15.1	96	155	845	123	26.3	60	5.0
	239	59	183	83.7	9.4	5.6	22.5	20.8	21.6	76	103	331	81	22.8	45	3.5
	240	59	169	68.2	4.4	3.9	12.6	7.8	12.9	83	125	600	99	31.5	38	3.3
	241	56	171	66.0	8.8	3.4	8.0	7.0	13.3	87	132	669	94	32.4	49	5.0
	242	58	173	76.5	8.7	4.4	13.2	20.4	19.0	87	125	628	81	29.3	42	3.9
	243	57	164	74.5	12.8	7.4	21.8	33.2	25.0	101	133	316	114	14.0	41	2.8
	244	58	176	80.0	12.2	7.3	18.7	13.9	20.4	64	139	670	81	24.3	50	4.2
	245	56	180	89.1	11.6	4.1	20.5	15.0	20.2	107	144	606	110	18.6	60	3.4
	246	56	169	68.2	10.6	6.3	16.2	8.4	17.4	74	134	628	81	28.7	51	3.2
	247	59	175	85.0	6.2	3.6	11.0	11.1	14.3	83	127	516	102	21.2	44	3.7
	248	58	180	96.6	20.2	12.0	22.6	20.4	25.0	107	146	626	106	17.2	53	4.0
	249	56	176	85.0	11.8	4.8	20.2	16.0	20.6	91	129	704	93	27.6	58	3.0
	250	59	167	64.0	8.8	5.6	21.0	12.6	19.4	109	136	340	117	16.7	44	1.3
	251	59	180	85.0	11.2	5.3	12.8	12.5	17.5	73	123	602	75	26.2	50	3.5
	252	56	178	88.3	11.4	6.6	21.3	23.1	22.5	97	133	483	110	17.5	50	4.4
	253	59	182	82.5	8.0	5.2	12.6	10.0	15.7	86	127	626	94	26.2	57	4.1
	254	59	174	95.5	12.8	4.0	26.4	19.1	22.4	71	94	474	69	36.0	53	3.6
	255	56	170	65.9	7.2	3.2	12.6	6.1	13.1	87	147	608	107	24.3	47	3.9
	256	59	180	88.7	11.0	5.4	20.8	12.0	20.0	77	118	660	86	29.9	48	4.5
	257	57	177	68.2	5.0	3.0	10.4	7.4	11.9	63	125	532	73	28.1	45	5.0
	258	56	180	87.0	11.4	6.0	13.7	14.0	18.5	77	138	658	100	22.2	50	4.0
	259	59	173	82.6	6.1	3.8	11.0	7.8	13.0	72	159	711	119	19.7	45	4.3
	260	56	175	65.5	8.2	3.2	6.8	7.4	12.0	70	134	841	106	39.5	45	0
	261	59	177	84.6	11.4	5.4	12.8	12.4	17.6	78	144	793	98	25.3	51	4.7
	262	57	175	71.0	6.6	2.9	9.5	8.3	12.4	80	129	628	83	29.7	45	3.9
	263	56	178	63.5	4.4	2.7	6.5	4.3	7.5	77	143	785	104	33.8	50	4.0

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
60-64	264	60	177	65.5	8.2	5.6	12.1	10.8	16.0	101	141	674	113	27.9	43	3.8
	265	60	175	73.7	10.4	5.5	18.5	10.2	18.4	70	134	616	81	25.0	47	4.0
	266	60	180	93.6	17.3	11.8	11.0	19.0	21.8	114	142	600	120	17.2	71	4.7
	267	62	167	63.7	9.4	5.5	17.0	10.5	17.7	77	147	654	87	25.8	45	3.7
	268	64	170	71.8	8.3	5.7	12.3	12.2	16.5	67	142	669	104	24.9	45	3.9
	269	61	175	75.0	7.0	4.0	10.0	17.0	16.4	76	121	606	83	29.6	50	4.2
	270	63	174	77.2	9.8	4.0	11.7	17.0	17.8	73	146	722	111	23.7	36	2.6
	271	62	183	86.2	12.6	3.6	13.8	7.5	16.2	70	144	638	104	19.4	57	4.8
	272	64	175	63.6	8.8	4.4	11.6	11.4	15.9	83	150	513	113	19.8	51	3.7
	273	64	173	65.4	6.8	4.8	13.9	13.4	16.7	91	132	455	110	21.7	44	3.3
	274	63	171	71.3	8.0	3.6	16.2	7.8	15.7	80	137	669	100	26.7	47	3.2
	275	61	173	74.2	9.1	4.3	13.5	10.5	16.2	48	99	618	60	49.2	49	3.9
	276	62	160	70.0	8.0	4.6	10.0	8.6	14.0	62	124	620	83	30.7	36	4.0
	277	61	173	85.5	11.2	5.4	15.4	30.0	22.3	95	159	833	123	21.3	48	4.4
	278	63	0	56.4	9.2	3.6	12.2	6.6	14.2	66	134	553	90	29.4	36	2.6
	279	62	170	84.5	15.2	8.6	20.9	13.4	21.6	92	103	150	92	10.7	39	3.0
	280	64	174	80.5	11.4	6.3	16.6	17.6	20.4	65	118	500	73	24.2	39	3.9
	281	63	177	68.1	7.7	3.4	12.3	10.0	14.8	61	140	711	73	28.6	47	3.9
	282	61	175	101.3	15.3	11.3	26.5	21.4	24.9	102	140	525	112	14.4	56	3.5
65-69	283	69	178	91.0	17.2	8.1	25.4	28.8	25.9	77	120	614	94	24.0	49	4.3
	284	65	176	67.3	5.2	4.0	13.0	12.4	15.3	81	143	486	94	18.5	49	4.2
	285	66	160	56.3	8.4	3.8	12.0	6.8	13.9	76	123	450	87	27.4	28	2.8
	286	68	174	84.2	10.2	6.6	13.5	7.6	16.3	73	116	632	90	28.7	35	4.1
	287	65	179	85.5	12.4	6.2	22.5	19.4	22.3	81	110	303	65	16.0	49	4.0
	288	67	168	72.7	7.4	4.7	20.0	21.1	20.6	66	134	600	101	23.6	40	2.6
	289	67	172	82.0	14.8	5.0	13.6	20.2	20.7	74	111	610	82	31.4	35	3.8
	290	65	173	82.8	10.4	3.8	23.2	19.4	21.3	77	118	608	74	27.1	43	3.8
	291	65	184	83.6	9.0	5.1	12.6	8.7	15.6	77	123	616	96	24.9	53	6.1
	292	65	173	77.7	9.2	4.4	12.6	11.4	16.3	62	104	749	62	47.3	49	3.9
	293	66	165	66.0	5.3	4.2	9.4	8.0	12.3	72	132	474	99	21.3	37	2.7
	294	69	158	79.0	14.8	10.2	19.2	15.8	22.0	84	144	626	101	19.8	40	2.8

AGE GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	295	68	170	69.5	6.6	3.8	10.1	7.0	12.5	66	106	616	66	41.8	39	3.6
	296	68	164	62.7	8.0	3.6	7.4	6.2	11.5	87	132	656	87	30.6	30	3.6
	297	65	171	72.7	9.4	6.0	13.8	12.1	17.4	85	159	551	90	16.0	39	3.2
	298	65	179	79.5	8.7	5.0	14.8	8.5	16.1	68	123	632	91	26.8	53	4.0
	299	67	174	67.3	7.3	3.3	7.3	6.5	11.2	70	138	525	74	21.2	37	3.2
	300	69	179	84.5	8.7	5.4	18.3	10.3	18.0	74	136	600	94	19.7	42	3.5
	301	68	178	78.5	17.2	8.1	15.0	19.1	21.9	63	141	636	80	21.0	29	3.2
70-+	302	70	177	63.4	6.0	3.2	10.4	6.8	12.0	86	132	624	85	27.5	39	3.9
	303	70	187	79.5	11.6	3.3	10.8	8.6	15.2	76	144	536	100	16.2	51	3.8
	304	70	183	82.5	13.2	3.5	10.6	11.4	16.6	78	122	600	94	23.8	43	3.7
	305	74	174	76.3	6.6	4.5	9.9	7.5	12.9	65	143	650	100	20.5	31	3.5
	306	79	167	67.4	7.5	3.1	10.0	8.3	13.0	65	118	505	81	25.3	31	2.2
	307	73	176	87.5	11.2	6.3	16.0	21.5	20.8	65	123	624	83	23.0	40	2.6
	308	72	167	61.4	6.4	3.6	10.8	5.8	11.7	94	129	609	95	29.0	38	3.1
	309	74	175	87.7	12.5	5.3	15.2	15.4	19.5	62	92	307	64	24.5	38	3.0
	310	85	172	67.2	10.6	3.0	8.1	8.4	13.5	67	114	440	68	24.1	44	3.2
	311	73	173	68.2	5.4	3.9	19.2	8.9	16.3	72	121	303	78	15.5	50	4.2
	312	76	165	61.4	7.4	3.9	9.6	8.8	13.4	70	114	455	72	27.1	32	2.6

TABLE XXVI

RAW DATA FROM THE SECONDARY STUDY

PARAMETERS*

*1 Subject number
2 Age - years
3 Height - centimeters
4 Weight - kilograms
5 Resting heart rate - beats/min.
6 Submaximal work load - kpm/min.
7 Submaximal work heart rate - beats/min.
8 Maximal heart rate - beats/min.
9 Actual MVO_2 - ml./kg./min.
10 Predicted MVO_2 - ml./kg./min.

AGE GROUP	1	2	3	4	5	6	7	8	9	10
30-34	01	34	184.0	83.9	115	830	163	188	35.8	30.5
	02	33	183.0	95.5	104	1008	172	200	43.0	29.6
	03	33	176.0	73.6	96	805	164	-	-	33.4
35-39	04	38	174.0	99.4	90	886	156	188	33.5	25.6
	05	39	164.0	72.8	62	1128	159	186	52.4	42.9
	06	36	175.0	59.8	73	864	170	196	50.5	36.2
	07	39	183.0	96.8	72	1117	150	196	37.5	35.3
	08	37	176.0	72.3	76	1002	159	195	42.1	38.5
	09	36	171.0	67.7	92	813	159	190	40.5	33.5
	10	38	175.0	79.6	84	1000	153	188	49.6	37.2
	11	38	175.0	70.9	72	1050	147	179	52.9	46.9
	12	39	177.0	96.4	87	970	143	159	31.5	33.5
	13	36	180.0	86.4	87	1078	158	188	43.8	34.9
	14	39	185.0	86.4	119	950	159	188	38.9	30.6
40-44	15	43	172.0	71.6	86	1023	166	196	46.1	35.2
	16	40	178.0	71.4	67	1059	159	193	53.4	39.2
	17	41	179.0	82.8	119	780	158	181	41.6	25.4
	18	43	179.0	85.4	74	936	159	-	-	29.1
	19	40	189.0	87.9	74	1047	129	177	43.3	45.8
	20	41	177.0	87.3	66	1105	147	175	45.8	38.2
	21	40	191.0	92.3	70	981	156	183	36.5	29.1
	22	41	182.0	76.8	64	951	161	179	38.6	32.2
	23	42	187.0	95.0	74	1169	139	183	43.1	41.0
	24	40	173.0	83.7	70	788	172	188	28.3	22.1
	25	43	177.0	79.6	105	780	161	196	42.4	25.6
45-49	26	45	175.0	66.5	72	918	139	183	48.6	43.5
	27	47	169.0	70.9	77	785	140	172	45.1	34.6
	28	46	172.0	67.7	77	793	147	179	35.3	33.6
	29	49	174.0	87.5	62	893	153	153	28.2	27.1

AGE GROUP	1	2	3	4	5	6	7	8	9	10
	30	46	176.0	81.8	78	981	161	193	33.4	29.2
	31	45	173.0	71.8	71	969	166	177	32.8	31.3
	32	47	180.0	74.1	85	1047	153	179	41.0	37.4
	33	45	189.0	97.8	89	897	146	163	23.6	26.5
	34	49	165.0	70.9	106	654	163	193	32.0	22.4
	35	47	188.0	96.6	84	991	163	175	30.4	24.5
50-54	36	53	177.0	81.9	72	1011	132	170	40.5	41.1
	37	52	170.0	81.9	62	843	146	172	32.4	28.6
	38	50	178.0	78.6	72	1234	150	183	48.1	41.3
55-59	39	55	187.0	81.4	79	1103	166	183	36.3	28.5
	40	55	173.0	84.6	65	829	125	166	38.8	34.6
	41	58	170.0	74.6	83	-	-	-	-	-
	42	56	175.0	86.4	68	904	144	179	31.4	28.1
	43	59	183.0	62.8	83	701	159	175	36.8	25.6
60-64	44	62	168.0	73.7	72	778	150	-	-	25.4
	45	61	171.0	65.5	63	624	127	-	-	31.5
	46	63	173.0	97.8	81	959	134	-	-	28.8
65-69	47	69	164.0	66.6	85	695	146	163	32.1	25.3